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Estimation and Determinants of Chinese Banks' Total Factor Efficiency: A New Vision Based on Unbalanced Development of Chinese Banks and Their Overall Risk.

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Estimation and Determinants of Chinese Banks' Total Factor Efficiency: A New Vision Based on Unbalanced Development of Chinese Banks and Their Overall Risk.

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Abstract: The development of shadow banking system in China catalyzes the expansion of banks' off-balance-sheet activities, resulting in a distortion of China's traditional credit expansion and underestimation of its commercial banks' overall risk. This paper is the first to incorporate banks' overall risk, endogenously into bank's production process as undesirable by-product for the estimation of banks' total factor efficiency (TFE) as well as TFE of each production factor. A unique data sample of 171 Chinese commercial banks, which is the largest data sample concerning with Chinese banking efficiency issues until now as far as we know, making our results more convincing and meaningful. Our results show that, compared with a model incorporated with banks' overall risk, a model considering on-balance-sheet lending activities only may over-estimate the overall average TFE and under-estimate TFE volatility as a whole. Higher overall risk taking of banks tends to decrease bank TFE through 'diverting effect'. However, significant heterogeneities of bank integrated TFE (TFIE) and TFE of each production factor exist among banks of different types or located in different regions, as a result of still prominent unbalanced development of Chinese commercial banks today. Based on newly estimated TFIE, the paper also investigates the determinants of bank efficiency, and finds that a model with risk-weighted assets as undesirable outputs can better capture the impact of shadow banking involvement.

Key Words: Total Factor Efficiency, Unbalanced Development, Shadow Banking, Global SBM
JEL Classification: C14, C33, G21

1. Introduction

During the past three decades, the Chinese banking sector has undergone strategic transformations in corporate governance, internal auditing functions and international development, with the joint efforts of banks and bank supervisory institutions. State-owned commercial banks (SOCBs) have transformed successfully from wholly state-owned commercial banks to shareholding companies by going public, recapitalizing and attracting strategic investors. Self-discipline and external supervisions are reinforced through the liberalization of both quantity

and price as well as the introduction of competition from foreign banks. Cross-border activities and overseas development strategies of Chinese banks are also encouraged by the government in a prudent manner. On the whole, positive progresses have been made in the enhancement of the core competitiveness and performance of Chinese banks. Figure 1 depicts the change in nonperforming loan (NPL) ratio and provision coverage ratio of Chinese commercial banks between 2006 and 2012. As shown in the figure, all types of Chinese commercial banks including large commercial banks, joint-stock commercial banks, city commercial banks and rural commercial banks experienced a decreasing trend of NPL ratio, with an average NPL ratio dropping from 7.1% to 1%. At the same time, provision coverage ratio of the whole commercial banking system increased from 34.3% to 295.5%, more than seven times larger than that in 2006.

Though China has made a lot of achievements in enhancing the performance of its commercial banking sector, challenges which are posing a threat to the further development of banks especially the improvement of bank efficiency still exist, with some new characteristics:

First, unbalanced development among banks of different types or located in different regions becomes even more prominent nowadays. Large commercial banks are experiencing a much faster reform and development speed than those small and medium banks. As shown in Figure 1, NPL ratio decreased significantly for large commercial banks, with an annual decreasing rate of 14.6% to 1% by the end of 2012, while that of the small and medium banks, especially rural commercial banks, decreased much slower. In 2008, NPL ratio of rural commercial banks exceeded the average NPL of the whole commercial banking system, becoming the banks with the highest NPL ratio in China until now. And even an increasing trend of NPL ratio for rural commercial banks was found from 2011 to 2012. The reasons for this unbalanced development among different types of banks are historical and institutional. Large commercial banks have long been regarded as the main pillar for the growth of the whole real economy, which enables them to get as many financial and material resources as possible from the government, such as the establishment of asset management companies (AMCs), capital injection with official international reserves or funds from issuing special treasury bonds and other policy supports. In contrast, small and medium banks have to self-digest their NPLs, and depend on their own shareholders and retaining profits for capital increase. The basic development strategy of 'reforming cities before rural areas' in financial system, totally different from the strategy of 'reforming rural areas before cities' in real economic system, is another reason for the dispersion of the development between city commercial banks and rural commercial banks. Besides, banks in different regions of China also show different extents of developments. The changes of the institutional environment of Chinese banks, caused by a number of market-oriented reforms, developed in a very unbalanced way across different provinces (Zhang, Wang and Qu, 2012). Limited number of bank branches, deposit and loans resources may restrict the performance enhancement of banks located in the middle and west of China.

Second, the development of shadow banking system[1] in China catalyzes the expansion of banks' off-balance-sheet activities, resulting in a distortion of China's traditional credit expansion and underestimation of its commercial banks' overall risk. Different from the shadow banking system in developed countries which is mainly based on financial markets, Chinese shadow banking develops relying on those traditional commercial banks. Banks provide funds, liquidity and help selling the products for the shadow banking, and at the same time banks themselves

[1] More detailed information about Chinese shadow banking system can be found in the third section of the paper.

transfer their on-balance sheet credits to off-balance sheet assets to escape supervisory regulations and get intermediate income. According to a report by the Chinese Orient Securities (2013), the volumes of real economy-supported shadow banking (tier-1) and financial transaction supported shadow banking (tier-2) amounted respectively to 30.3 trillion (RMB) and 22.34 trillion (RMB) by the end of 2012, accounting for 45.03% and 33.20% of the total Chinese bank loans denominated in both domestic and foreign currency.[2] Figure 2 describes the changes of the volume of Chinese shadow banking (tier-1) during the period 2002-2012. As shown in the figure, following a relatively slow growth of shadow banking before 2005, both shadow banking volume and the ratio of shadow banking to total bank loans[3] experienced their first round of growth between 2005-2009, with shadow banking volume growing from 27.76 trillion (RMB) to 110.98 trillion (RMB) and the ratio of shadow banking volume to total bank loans growing from 13.41% to 26.08%. The ratio of shadow banking volume to aggregate financing to the real economy reached a peak of 32.64% in 2007 during this period. The second round growth of shadow banking system began in 2009, triggered by the strong credit demand and funding strains implemented by the policy authority (HSBC, 2011)[4]. Larger increase in the shadow banking volume and the ratios of this volume to total bank loans and aggregate financing to the real economy were evident, with shadow banking volume growing from 110.98trillion (RMB) to 302.98 trillion (RMB) and the ratio of shadow banking volume to total bank loans growing from 26.08.41% to 45.03%.The ratio of shadow banking volume to aggregate financing to the real economy increased by 17.77%, reaching 42.14% by the end of 2012.

How will the change of Chinese commercial banks' overall risk, resulted from their involvement in shadow banking activities, impact the performance and efficiency of Chinese commercial banks nowadays? When this new characteristic is considered, will the evolution of efficiency differ among banks of different types or located in different areas? And what are the determinants of Chinese commercial banks' efficiency after accounting for their overall risk? Unfortunately, though more and more studies try to highlight the impact of risk on bank efficiency (Chiu, Chen and Bai, 2011; Chen, 2012; Saeed and Izzeldin, 2014), none of them, to the best of our knowledge, fully incorporate a bank's overall risk including off-balance sheet risk as an undesirable by-product of its asset production process into the measurement of bank efficiency. Most of the studies try to treat risk measures as control variables and analyze the impact of risk on bank efficiency after the estimation of efficiency(Sun and Chang, 2011;Hou, Wang and Zhang, 2014) or include NPLs, which only capture a bank's on-balance sheet credit risk, as an undesirable by-product output arising from the production of loans. Besides, existing studies concerned with Chinese bank issues also have the drawback of limited data samples, which may lead to biased efficiency estimation. Rural commercial banks including those cooperative financial institutions, which have played a significant role in rural development, and a comparison between banks located in different regions of China are absent in all of the existing literature.

Thus, our paper contributes in the following ways: First, from a methodology perspective, we are the first paper to incorporate banks' overall risk, especially off-balance risk, endogenously into their asset production process as undesirable by-product for the estimation of banks' total factor efficiency (TFE). To highlight the importance of banks' overall risk, we also evaluate TFE with

[2] See the report of the Chinese Orient Securities (2013): "Shadow Banking: International Prospect and Chinese Case (Second Part)".
[3] The total bank loans include loans denominated by both domestic currency and foreign currency.
[4] Hu, Y., and D. Mahendran, 2011. "China Banks: Shadow Banking Conundrum" HSBC Global Research.

NPLs as undesirable outputs of bank production process. Second, our paper tries to overcome the drawback of limited data sample by investigating a unique sample of 171 Chinese banks, including 5 large commercial banks, 12 join-stock commercial banks, 103 city commercial banks and 51 rural commercial banks, which is the largest data sample until now as far as we know, making our results will be more convincing and meaningful; Third, We are also the first paper to highlight the differences in total factor bank efficiency among different categories of banks and different regions at the same time. The further disaggregation of total factor efficiency helps us explore the source of Chinese banks efficiency for each kind of bank and each region.

The remainder of the paper is structured as follows. Section II summarizes the related literature regarding this topic. Section III describes the structure and development of Chinese banking system. Section IV introduces our estimation methodology and regression model. Section V compares TFE among banks of different types or located in different regions of China, followed by TFE disaggregation and determinants analyses. Section VI concludes.

2. Literature Review

Our paper builds on two strands of literature: i) literature concerned with the estimation methodology of bank efficiency; ii) literature with regard to the determinants of bank efficiency. We will first summarize these literature, and then highlights our contributions by identifying relevant research gaps in the literature.

2.1 Estimation Methodology of Bank Efficiency

Parametric techniques, such as the distribution-free approach and stochastic frontier approach (Duygun, Sena and Shaban, 2013; Jiang, Yao and Feng, 2013; Tabak, Miranda and Fazio, 2013; Goddard, Molyneux and Williams, 2014)[5], and nonparametric techniques, such as data envelopment analysis (Holod and Lewis, 2011; Halkos and Tzeremes, 2013; Saeed and Izzeldin, 2014) are the most commonly used methodologies for the estimation of bank efficiency.[6] Compared with parametric techniques whose results heavily depend on how accurately the chosen functional form captures the true production relationship (Sun, Harimaya and Yamori, 2013) and other nonparametric techniques, data envelopment analysis (DEA) has been regarded as a better and robust efficiency analysis tool since it uses actual data from evaluated units to construct the efficiency frontier without setting up a specific functional form, and at the same time allows for the existence of random errors (Yang and Liu, 2012). Besides, DEA-based procedures perform better than parametric methods in the estimation of an individual decision-making unit (individual bank in our case) productivity (Banker and Natarajan, 2008). The work of Chortareas, Girardone and Ventouri (2012), Chortareas, Girardone and Ventouri (2013), Barth, Lin and Ma et al. (2013), Harris, Huerta and Ngo(2013) can all be recognized as representatives for the application of

[5] Goddard, Molyneux and Williams (2014) estimate bank efficiency of Latin American between 1985 and 2010 through an application of random parameters models for stochastic frontier analysis (SAF). Their analysis shows that on average the estimated mean efficiencies obtained from random parameters models tend to be higher than those obtained using fixed or random effects because random parameters models do not confound parameter heterogeneity with inefficiency. Tabak, Miranda and Fazio (2013) highlight the importance of taking into account the local environment and constraints while analyzing banks' performance by applying a geographically weighted stochastic frontier model for the evaluation of US saving banks' efficiency between 2001 and 2009.

[6] A very limited number of researches (Dima, Dinca and Spulbar, 2014; Beck, Demirgüc-Kunt and Merrouche, 2013) directly use financial ratios, such as overhead cost and cost to income ratio, as proxies of bank efficiency.

classical DEA in the estimation of bank efficiency. To perform more accurate efficiency evaluation, several modified DEA techniques have been exploited. Yang and Liu (2012) combine the network data envelopment analysis (NDEA) model which not only can do for modeling an organization but also for measuring the performance of its components, fuzzy approach, and multiple objective programming approach in the context of bank branch evaluation. Lin and Chiu (2013) integrate NDEA and independent component analysis (ICA) to evaluate the operational performance of the Taiwanese domestic banking sector. Chiu, Luo and Chen et al. (2013) apply Hybrid Meta-Frontier DEA approach which is first proposed by Tone (2004) and considers both radial variables and non-radial variables, taking into account the proportional and non-proportional changes in variables' characteristics, to evaluate the operational efficiency of banks in Taiwan.

However, none of these studies mentioned above have accounted for undesirable outputs, such as nonperforming loans (NPLs), when estimating the efficiency of banking sector. Just as Assaf, Matousek and Tsionas (2013) have pointed out, a bank that has high performance is not necessarily better than other banks if undesirable outputs are ignored in the performance evaluation, as it might achieve this at the expense of producing a high percentage of undesirable outputs. Not accounting for NPLs in estimating the frontier model might cause failures in crediting a bank for its effort to reduce undesirable outputs (Fernandez, Koop and Steel, 2002) and biased estimation results (Atkinson and Dorfman, 2005; Assaf, Matousek and Tsionas, 2013). To the best of our knowledge, only a few researches incorporate undesirable outputs directly as a part of bank production process in recent years. Park and Weber (2006), following the work of Berg, Forsund and Jansen (1992) which is the first to include the quality of assets (i.e. loan losses) into the model, investigate the efficiency of Korean banks from 1992 to 2002 by using a directional technology distance function. They treat NPLs as an undesirable by-product output arising from the production of loans. Fukuyama and Weber (2008) examine the extent of Japanese banking inefficiency by modeling non-performing loans as a jointly produced undesirable by-product of the loan production process. Their estimation is based on the directional output distance function which is introduced by Chambers, Chung and Färe (1996). More recently, Fujii, Managi and Matousek (2014) apply the weighted Russell directional distance model (WRDDM), which is a modification of traditional directional distance function model (TDDFM) and possesses the attractive advantages of easy computation and extension of incorporating the additional undesirable outputs into the programming problems, to measure productive inefficiency in Indian banking sector. Difference from the methodology of Fujii, Managi and Matousek (2014), Assaf, Matousek and Tsionas (2013) estimate the productivity and efficiency of Turkish banks from 2002 to 2010 by using a Bayesian stochastic frontier approach while accounting for nonperformance loans in the model.

Though the significance of the direct incorporation of undesirable outputs for evaluating bank efficiency has already been highlighted in a few studies, there are still several important gaps in the estimation of bank efficiency that need to be addressed:

First, most literature that integrate undesirable outputs in the production process of banking sector rely on directional distance function (DDF) methodology to measure the bank efficiency. However, this DDF approach assumes that the increase of desirable output and the decrease of undesirable output follow a similar proportion, which is too strict in the reality (Chen and Zhang, 2014). Besides, most of the efficiency measures in the literature are radial and angle, which make

it very likely to overestimate efficiency when there are non-zero slacks in the constraints (Fukuyama and Weber, 2009). Thus, this paper will try to overcome the drawbacks of DDF by applying the non-radial, non-angle global slacks-based measure (GSBM) approach[7] for the estimation of the actual banks' total factor efficiency in China.

Second, until now loan loss (Berg, Forsund and Jansen, 1992) and nonperforming loans (Fujii, Managi and Matousek, 2014; et al.) are the only undesirable outputs incorporated in the production process. As the impact of risk on bank efficiency gains more and more attention (Chiu, Chen and Bai, 2011; Chen, 2012; Saeed and Izzeldin, 2014), it is important to fully include endogenous risk into the measurement of bank efficiency. However, neither loan loss nor nonperforming loans, which mainly profile the credit risk resulted from banks' on-balance-sheet lending activity, can well capture the overall risk of banks, especially those off-balance-sheet risk exposure. In China, recent years have witnessed a significant surge in the off-balance activities of banks as a result of both strong credit demand and funding strains implemented by the policy authority (HSBC, 2011). Shadowing banking and off-balance-sheet risk exposure is regarded as one of the main factors threatening the stability of the whole Chinese banking system. Thus, to well capture the impact of this off-balance risk on bank efficiency, this paper tries to incorporate a wider risk measurement, i.e. risk-weighted asset which is the sum of a bank's on-balance-sheet and off-balance-sheet asset weighted according to their risk, as an undesirable output for evaluating bank efficiency. To be noted, different from those literature which treat risk measures as control variables and analyze the impact of risk on bank efficiency after the estimation of efficiency(Sun and Chang, 2011; Hou, Wang and Zhang, 2014), we directly model risk assets as a jointly produced undesirable by-product of the asset production process, and we are also the first paper to try to incorporate this wider risk measurement, which captures off-balance-sheet risk exposure, as an undesirable output into the model. Besides, a comparison is made between the estimated total factor efficiency accounting for nonperforming loans and the total factor efficiency accounting for risk weighted assets, to highlight the differences.

Third, though many studies have tried to evaluate the efficiency of Chinese banking sector, few of them accounts directly in their model for an undesirable output. Almost all of the studies are based on stochastic frontier approach (Sun, Harimaya and Yamori, 2013; Yin, Yang and Mehran, 2013) or DEA approach (Hou, Wang and Zhang, 2014; Dong, Hamilton and Tippett, 2014) without undesirable by-product, resulting in distorted estimations of the real efficiency of Chinese banking. To our knowledge, Wang and Zhu (2011a, 2011b) are the only persons in China who have incorporated undesirable output into the bank production process. However, their analysis considers only non-performing loans and covers only 27 commercial banks in China, far from the total number of banks with public information. Other studies concerned with Chinese bank issues also have the same drawbacks for their limited data samples. Most of them, such as Jiang, Yao and Feng (2013), Fungáčová, Pessarossi and Weill (2013),Dong, Hamilton and Tippett (2014) et al., use a sample comprising less than 80 Chinese commercial banks. Zhang, Wang and Qu(2012) and Yin, Yang and Mehran (2013) estimate the bank efficiency based on a sample of 133 Chinese banks, which is the largest sample that has been used so far. Besides, rural commercial banks including those cooperative financial institutions, which have played a significant role in rural development, are absent in all of the existing literature. This paper tries to

[7] More information about slack-based measure (SBM) can be read in the work of Tone(2001), Färe and Grosskopf (2010). To be noted, though Fukuyama and Weber (2009) propose a directional slacks-based measure to evaluate the technical inefficiency of Japanese banks, they haven't accounted for undesirable outputs.

overcome these drawbacks by investigating a unique sample of 171 Chinese banks, including 5 large commercial banks, 12 join-stock commercial banks, 103 city commercial banks and 51 rural commercial banks. Due to better data quality, our results will be more convincing and meaningful. We are also the first paper to highlight the differences in total factor bank efficiency among different categories of banks and different regions at the same time. The further disaggregation of total factor efficiency helps us explore the source of Chinese banks efficiency for each kind of bank and each region.

2.2 The Determinants of Bank Efficiency.

The second strand of literature related to our paper investigates the determinants of bank efficiency. It has long been recognized that bank characteristics, market competition, policy environment all play a significant role in determining bank efficiency.

For the influence of bank characteristics on the efficiency, Hsiao, Chang, Cianci et al. (2010) support that banks with lower nonperforming loans and higher capital adequacy ratios are associated with higher operating efficiency. They attribute the improved efficiency in post-reform period of Taiwan to the enhancement in banking and risk management practices. Cyree and Spurlin (2012) show the significance of bank size in the determination of efficiency and they argue that when a big bank is present in a rural market, a small bank in that market has lower levels of profit efficiency. A smaller decrease in the efficiency of small banks will appear as the number of big banks in a rural market increase. Besides capital and bank size et al., ownership structure is also identified to be an important factor for bank efficiency. Yang and Liu (2012) present that the overall performances of mixed ownership bank branches are superior to those of state-owned bank branches in Taiwan, representing that the advantages of banking privatization have some remedial effects for improving the managerial inefficiency of state-owned banks. In contrast, Goddard, Molyneux, and Williams (2014), after analyzing the cost efficiency for Latin American, find that the mean rank cost efficiency of privately-owned banks in Mexico declined faster than that of state-owned banks.

According to the existing literature, the impact of market competition on bank efficiency is mixing. Maudos and Guevara (2007) supports a negative relationship between market competition and bank efficiency, after examining the impact of market power in the loan and deposit markets on bank efficiency for 15 European countries over 1993–2002. Their results show the existence of a positive relationship between market power and cost X-efficiency. However, Hou, Wang and Zhang (2014) argue that the lower market power caused by intense market competition tend to improve technical efficiency, for banks are compelled to develop advanced technical experience and skills and they support their argument by analyzing 44 major Chinese commercial banks between 2007 and 2011. Different from Maudos and Guevara (2007), Hou, Wang and Zhang (2014) et al., Duygun, Sena and Shaban (2013) try to quantify the impact that the Schumpeterian competition mode, i.e. competition through the launch of new products, has on the cost and profit efficiency of the UK commercial banks and the results show that the competition intensity in the commercial banking sector does affect negatively the mean cost and profit efficiency in the sector but there is evidence that as competition intensity increases in the sector, commercial banks react by improving their cost and profit efficiency.

As for the policy environment, regulatory and supervisory policies are regarded as one of the

most important determinant of bank efficiency. Gaganis and Pasiouras (2013), by using a large sample of nearly 4000 commercial banks operating in almost 80 countries, find that bank efficiency decreases as the number of the financial sectors that are supervised by the central bank increases and banks in those countries with greater unification of supervisory agencies also tend to be less profit efficient. However, Chortareas, Girardone and Ventouri (2012), Barth, Lin and Seada et al. (2013) argue that the impact of regulatory and supervisory policies on commercial bank efficiency depends on the concrete form of policies. Based on an un-balanced panel analysis of 4050 banks observations in 72 countries over the period 1999–2007, Barth, Lin and Seada et al. (2013) show that tighter restrictions on bank activities are negatively associated with bank efficiency, while greater capital regulation stringency is marginally and positively associated with bank efficiency. A strengthening of official supervisory power is positively associated with bank efficiency only in countries with independent supervisory authorities. Besides regulatory and supervisory policies, Harris, Huerta and Ngo (2013) examines the impact of the Troubled Asset Relief Program (TARP) capital injections on the operational efficiency of American commercial banks and they find that banks receiving the capital injection from TARP tend to have lower operating efficiency as a result of the abated incentives of bank managers to adopt best practices that improve asset quality, and the moral hazard associated with bailouts. Chortareas, Girardone and Ventouri (2013) suggest that the higher the degree of an economy's financial freedom, the higher the benefits for banks in terms of cost advantages by investigating a large sample of commercial banks operating in the 27 European Union member states.[8]

Recent years also see an extensive literature dedicated to explain the evolution of Chinese bank efficiency. Zhang, Wang and Qu(2012) show that the efficiency of Chinese city commercial banks is heavily influenced by the effectiveness of law enforcement in the region. Better legal environment, higher efficiency in the legal system, and stronger protection of intellectual property right are associated with a higher level of efficiency among these banks. Sun, Harimaya and Yamori (2013) investigate the effect of strategic investors on bank efficiency in the context of regional economic development. Their analysis shows a positive role of strategic investors in enhancing the efficiency of Chinese city commercial, and this positive effect is negatively correlated to the level of regional economic development. Yin, Yang and Mehran (2013) support the positive effect of WTO accession on bank efficiency. The largest banks with substantial state ownership have enjoyed a more prominent improvement in efficiency. Jiang, Yao and Feng (2013) appraise the privatization of banks for its significant role in improving performance with respect to revenue inflow and efficiency gains in the short-run or long-run (initial public offerings). However, as mentioned before, the estimated bank efficiency which is used for further analysis may be biased due to the drawbacks results from limited data sample or estimation methodology. Thus, it is pretty necessary to reanalyze the evolution of Chinese bank efficiency and their determinants based on improved data sample and methodology. Besides, to well illustrate the bank efficiency, the impact of the development of shadow banking on bank efficiency should also be checked.

3. Chinese Banking System: an Overview

The banking system in China is the largest and most complex among the countries presently in

[8] For more work about the determinants of bank efficiency, we can refer to Fu and Heffernan(2009), Fungáčová, Pessarossi and Weill (2013), Fujii, Managi and Matousek (2014) et al.

transition from central planning to market-based economies (Lin and Zhang, 2009). It has undergone a series of significant transformations since 1978. A good knowledge of the structure and development of Chinese banking system will help us better understand of the evolution and determinants of bank efficiency.

3.1 A Multi-Tier Banking System

By the end of 2012, the Chinese banking sector consists of 2 policy banks and China Development Bank (CDB), 5 large commercial banks, 12 joint-stock commercial banks, 144 city commercial banks, 337 rural commercial banks, 147 rural cooperative banks, 1927 rural credit cooperatives(RCCs), 1 postal savings bank, 4 banking assets management companies, 42 locally incorporated foreign banking institutions, 67 trust companies, 150 finance companies of corporate groups, 20 financial leasing companies, 5 money brokerage firms, 16 auto financing companies, 4 consumer finance companies, 800 village or township banks, 14 lending companies and 49 rural mutual cooperatives (CBRC, 2012)[9], where large commercial banks, joint-stock commercial banks, city commercial banks, rural commercial banks jointly constitute the whole Chinese commercial banking system[10]. Figure 3 shows the market share of banking institutions in terms of assets from 2003 to 2012. As what we can learn from the figure, the total market share of large commercial banks witnessed a continuously decreasing trend, from 58.03% at the end of 2003 to 44.93% at the end of 2012. While the market shares of other three types of Chinese commercial banks all kept increasing over the period, with the share of joint-stock commercial banks increasing from 10.70% to 17.61%, the share of city commercial banks increasing from 5.29% to 9.24%, and the share of rural commercial banks increasing from 0.14% to 4.70%. The share of policy banks and the CDB changed little during this period, and the share of other banking institutions experienced a decreasing trend to 15.13% by the end of 2012.

Though homogeneous competition and business model is evident in Chinese commercial banks nowadays (Ba, 2013), different types of commercial banks still have different comparative advantages in sponsoring economic development. The Large commercial banks, including Agricultural Bank of China (ABC), Bank of China (BOC), China Construction Bank (CCB), Industrial and Commercial Bank of China (ICBC), Bank of Communications (BOCOM), which still rank in top five, have played a significant role in providing credit to state-owned enterprises (SOEs) and big projects, for their pretty large branch networks and asset values. While the geographical coverage and asset values are much smaller for other commercial banks, especially city commercial banks and rural commercial banks. Generally speaking, joint-stock commercial banks (JSCBs), which mainly provide loans to small SOEs and firms with partial private ownership including small and medium enterprises (SMEs), tend to expand their branches in the regions of origin or in those coastal areas with good economic perspectives, though they are also regarded as national banks in China (García-Herrero, Gavilá and Santabárbara, 2006). The largest five joint-stock commercial banks in terms of asset values by the end of 2012 are Merchants Bank, Evergrowing Bank, China Minsheng Banking Corporation, Shanghai Pudong Development Bank and China Citic Bank. Different from large commercial banks and joint-stock

[9] Refer to the annual report of CBRC (2012), website: ttp://www.cbrc.gov.cn/chinese/home/docViewPage/110007.Html.

[10] Foreign banks also belong to the commercial banking system, according to the definition of CBRC. Here we mainly focus on Chinese banks.

commercial banks, city commercial banks and rural commercial banks typically aim at financing SMEs, especially those located in their own administrative regions, and supporting development policies of local governments. Some are even regarded as the "second finance" of local governments (Qian and Cao et al., 2011).

3.2 The Reform of Chinese Commercial Banking System[11]

3.2.1 First Stage of the Reform (1978-1993)

In the first stage of financial reform, commercial banking activities and foreign exchange transactions etc. were removed from the People's Bank of China (PBC), through the establishment of 4 wholly state-owned commercial banks (SOCBs or the 'Big Four'). Before 1979, Chinese financial system was a mono-bank system where PBC took charge of a series of issues such as deposit-attracting, commercial lending, monetary policy implementation, foreign reserve management and so on, with fairly low operating efficiency. To solve this multi-task status of PBC and improve the operation of banking system, three of the 'Big Four', Agricultural Bank of China (ABC), Bank of China (BOC), China Construction Bank (CCB), which specialized in fostering and supervising rural banking activities, carrying out foreign currency transactions and supporting the construction sectors respectively, were established in 1979. This specialization of operating kept until the end of 1985, one year after the last one of the 'Big Four' i.e. Industrial and Commercial Bank of China (ICBC) was established, and since then all the 'Big Four' members could enter any business field which was allowed by the PBC and compete with each other.

Rural credit cooperatives (RCCs) and urban credit cooperatives (UCCs), which were mainly under the control of local governments and aimed at financing small and medium enterprises (SMEs),were stablished during this stage as well to sponsor development of the areas with scarce resources. They attract deposits from small towns or rural areas.

3.2.2 Second Stage of the Reform (1994-2002)

Due to the soft-budget constraints for SOEs loans, weak credit culture (García-Herrero, Gavilá and Santabárbara, 2006) and also the poor management (Sun, Harimaya and Yamori, 2013), nonperforming loans (NPLs) increased significantly during this period in both the SOCBs and UCCs. To ameliorate this problem and improve the performance of commercial banks, a lot of efforts were made by the government:

Four asset management companies (AMCs), legally independent agencies with a very broad mandate, were created in 1998 for the cleaning-up of non-performing loans of the SOCBs. These AMCs not only took charge of the reconstruction of NPLs including converting them to equity, but also had the responsibility to pay for the NPLs they received. Besides, the Ministry of Finance injected 270 billion RMB, which was financed through the issue of 30-year government special bonds, into the SOCBs to improve the balance sheets of them.

For UCCs, the government tries to ameliorate their NPLs problem by consolidating all the UCCs, part of the RCCs and local financial institutions located in towns into newly formed

[11] Based on the work of García-Herrero, Gavilá and Santabárbara (2006), Berger, Hasan and Zhou (2009), Lin and Zhang (2009) , Chang, Hu, and Chou et al. (2012), Sun, Harimaya and Yamori (2013), Liang, Xu and Jiraporn (2013).

joint-stock companies, namely city commercial banks, which inherited all NPLs from UCCs and at the same time got injections from local public funds (Sun, Harimaya and Yamori, 2013). These cities commercial banks are not allowed to set up branches in any other area outside their own administrative regions until 2006.

Market practices began to be introduced during this period: The establishment of three policy banks, i.e. the Agricultural Development Bank of China (ADBC), China Development Bank (CDB), and the Export–Import Bank of China (Chexim) in 1994 enabled SOCBs to get rid of policy-lending activities and focus on only commercial business, making them to be more profit-oriented; SOCBs were also encouraged to manage their own assets and take more responsibility for their own lending decisions, through the reduction of reserve requirements and the removal of some credit quotas; Government interference in commercial lending was forbidden in 1999, at least in formal terms, and private capital was allowed to enter JSCBs and CCBs (García-Herrero, Gavilá and Santabárbara, 2006).

3.2.3 Third Stage of the Reform (2003-Current)

This stage of the reform is mainly characterized by the establishment of China Banking Regulatory Commission (CBRC), ownership reform of SOCBs, development of initial public offerings(IPOs), foreign strategic attraction and so on.

In 2003, CBRC was established by the government, to take over the regulatory and supervisory functions of the banking sector from the PBC who was mainly responsible for monetary policies from then on. Its objectives include protecting consumers and depositors, maintaining the stability in the banking system, enhancing banks' competitiveness, encouraging competition, educating the public on the role of finance and eradicating financial crime. To this end, it focuses on the strength of financial institutions, capital adequacy issues, and the restructuring of the banking sector. At the same time, the CBRC, itself, is enhancing its transparency through the publication of individual bank data, including NPLs (García-Herrero, Gavilá and Santabárbara, 2006).

Another important reform was the successful transformation of SOCBs from wholly state-owned banks to shareholding companies by going public and recapitalizing. A total amount of 37.5 billion (USD) capital was injected in to SOCBs in 2003 and 2005, with CCB and BOC which is the two best-performing banks then receiving 22.5 billion in 2003 and ICBC receiving 15 billion. The capital all collected from the official international reserves, by selling US government bonds. At the same time, CCB, the first bank in China to go public, was listed on Hong Kong Exchange for 8 billion (USD) in October 2005 and on Shanghai Stock Exchange for 7.6 billion (USD) in September 2007. BOC and ICBC raised 13.7 billion (USD) and 21.9 billion (USD) respectively in 2006 through the listing in both Hong Kong Exchange and Shanghai Stock Exchange. ABC was the last one in the 'Big Four' to go public. It made an initial public offering for 11.98 billion (USD) in Hong Kong Exchange and for 10.12 billion (USD) in Shanghai Stock Exchange in July 2010. Besides, BOCOM was also incorporated as the SOCBs by the CBRC in 2007 for its large asset value. Ever since then, the 'Big Four', together with BOCOM, were named as 'large commercial banks' in China.

The attraction of strategic investors is also encouraged by the government during this period, to improve the governance structure and management performance of Chinese banks. According

to Ma (2006), the total declared foreign direct investment (FDI) in Chinese banks reached 16.5 billion (USD) by late 2005, accounting for approximately 15 percent of the banking sector's core capital. Moreover, in January 2006, Goldman Sachs Group Inc., Allianz AG, and American Express Co., signed an agreement to buy a total 10% stake of ICBC for $3.78 billion, and Goldman Sachs has been providing staff training, risk-management assistance and guidance on internal control and corporate governance (Berger, Hasan and Zhou, 2009).

3.3 New Characteristics of Chinese Commercial Banks in Recent Years

Recent years have witnessed a series of new characteristics of Chinese commercial banks: Unbalanced development among banks of different types or located in different regions becomes even more prominent; The development of shadow banking system in China catalyzes the expansion of banks' off-balance-sheet activities, resulting in a distortion of China's traditional credit expansion and underestimation of its commercial banks' overall risk. As the unbalanced development of Chinese banks is already introduced in detail in the first section of the paper, we here mainly introduce Chinese shadow banking and its relationship with traditional commercial banks to help us better understand the underlying risks especially those off-balance-sheet risks Chinese banks are now confronted with.

Generally, Chinese shadow banking system can be categorized into three kinds[12]: The first kind, which is called real economy-supported shadow banking (tier-1), refers to the shadow banking instruments and activities providing financing for the real economy, such as bank acceptances, entrusted loans, letters of credit (L/Cs), financial leasing and other informal lending; The second kind, which is named as financial transaction-supported shadow banking (tier-2), refers to the shadow banking instruments and activities supporting financial transactions in capital markets, such as wealth management products (WMPs), public offering of fund, social insurance fund, insurance asset management and so on; The last kind refers to the shadow banking instruments and activities related to financial derivatives, which is called leverage-amplification shadow banking (tier-3), such as credit risk mitigation (CRM) and so on.

Here, we mainly introduced entrusted loans and WMPs, two of the most important forms of shadowing banking in China today. Entrusted loans are essentially inter-corporate lending in China, with lenders setting up all the terms with targeted borrowers (including size, maturity, yield, and collateral). Banks therefore act as intermediaries and trustees to legalize the process and charge 20-30bp as fee income. Banks may be confronted with risks for the high proportion borrowers from property sector as well as the weak credit profile of these borrowers (HSBC, 2011). Different from entrusted loans, WMPs are investment management plans sold by banks (HSBC, 2011). Usually banks collect short-term funds through the issuing of WMPs and invest them in long-term assets including bonds, stocks, bank loans and portfolios etc., which is quite similar to the operation model of SIV in developed countries. In 2012, 47.71% of the funds raised by WMPs were invested into bond and money market and 38.47% went into portfolio investments. While only 0.36% were invested into bank loans, after the implementation of strict restrictions on loan markets in 2010.[13]

[12] Refer to the report of the Chinese Orient Securities (2013): "Shadow Banking: International Prospect and Chinese Case (Second Part)".
[13] Data source: The report of the Chinese Orient Securities (2013): "Shadow Banking: International Prospect and Chinese Case (Second Part)".

Most of the shadow banking instruments and activities in China depend heavily on traditional commercial banks, obtaining liquidity supports and selling products through commercial banks, which leads to a surge in banks' off-balance activities and underestimation of banks' overall risk. Figure 4 shows the corporation model among commercial banks (CBs), securities companies (SCs) and trust companies (TCs) in the operating of WMPs. As shown in the figure, traditional commercial banks exert a key role in making investment and operating decisions, while securities companies and trust companies usually function as channels in case of WPMs.

4. Methodology

4.1 Estimation Methodology: Global SBM Approach

Different from the directional slacks-based measure (SBM) approach applied by Fukuyama and Weber (2009), Global SBM…….

Specifically, to capture the impact of the whole bank risk on the efficiency, especially the off-balance-sheet risk exposure, we will consider two models here: Model 1 incorporates risk-weighted assets as an undesirable output; Model 2 incorporates non-performing loans as an undesirable output. All the inputs and desirable outputs are the same for these two models. To be noted, as bank loans itself constitute one of the most important parts of total assets, we haven't modeled both risk-weighted assets and non-performing loans as undesirable by-products of the same production process to avoid possible high correlation between these two variables.

The chosen of the remaining input and desirable output variables is also an important issue for the modelling of bank production process. Compared with the production approach which is more appropriate for evaluating the efficiency of bank branches (Berger and Humphrey, 1997), the intermediation approach has been widely used for the estimation of bank efficiency, including the valuation of Chinese banks' performance (Fungáčová, Pessarossi and Weill,2013; Hou, Wang and Zhang, 2014; et al.). It emphasizes the main function of the bank as a financial intermediary, collecting deposits to transform them with labor and capital etc. into loans and other outputs. Though most of the literature focusing on Chinese issues model the production process use this approach, the input variables chosen for the estimation is limited and usually differ greatly from one to another, which make it very likely to miss the impact of certain important input on the production process and result in distorted efficiency. Chang, Hu and Chou et al.(2012) encompass total deposit and short-term funding, total fixed assets and total numbers of bank employees as inputs, while Zhang, Wang and Qu(2012) incorporate interest expense, operating expenses and net value of fixed assets and Yin, Yang and Mehran (2013) include fixed assets, deposit and equity as input variables. To well reflect the true contribution of each input to the banks' TFIE, we include as much as input variables for the production process, while at the same time guarantee that any two of these input variables have no overlapped part. Concretely, our input factors include total deposit, equity, net value of fixed asset, numbers of employees, interest expense, administration expense and operating expense from which administration expense is subtracted. For desirable output, following Wang and Zhu (2011), we incorporate perform loans, equaling total loans minus nonperforming loans, and pre-tax net profit into the model.

Assume there are n decision-making units (DMU) at time t. For each DMU, there are k inputs, l desirable outputs and m undesirable outputs. x, y, b, X, Y and B represent the column

vector and matrix of inputs, desirable outputs and undesirable outputs, respectively. Here, the DMUs are 171 banks in China. $k = 7$ for total deposit, equity, net value of fixed asset, numbers of employees, interest expense, administration expense and operating expense, $l = 2$ for perform loans and pre-tax net profit, $m = 1$ for nonperforming loans in Model 1 and for risk-weighted assets in Model 2. The production set P could be defined as:

$$P = \{(x, y, b) \mid x \geq X\lambda, y \leq Y\lambda, b \geq B\lambda, \lambda \geq 0\} \tag{1}$$

The global SBM TFE for i-th DMU could be obtained by resolving the following fraction programming:

$$TFIE^{t}_{NPL}(x^{t}_{i}, y^{t}_{i}, b^{t}_{i}) = \min \frac{1-(1/k)\sum_{k=1}^{k}(s^{x,-}_{k} / x^{t}_{k,i})}{1+[1/(l+m)][\sum_{l=1}^{l} s^{y,+}_{l} / y^{t}_{l,i} + \sum_{m=1}^{m}(s^{b,-}_{m} / b^{t}_{m,i})]} \tag{2}$$

$$s.t. \quad x_i = X\lambda + s^{x,-}_{i}; \quad y_i = Y\lambda - s^{y,+}_{i}; \quad b_i = B\lambda + s^{b,-}_{i}$$

$$s^{x,-}_{i} \geq 0; \quad s^{y,+}_{i} \geq 0; \quad s^{b,-}_{i} \geq 0; \quad i'\lambda = 1; \quad \lambda \geq 0$$

where $TFIE$ presents the total factor integrated factor of the unit. $s^{x,-}_{i}$, $s^{y,+}_{i}$, $s^{b,-}_{i}$ represent the over-inputs, under-desirable outputs and over-undesirable outputs, respectively, referred to as the slack variables. λ is the intensity vector, the summation of its elements being 1 indicating the assumption of varying return to scale (VRS). The value of this score lies between 0 and 1, and the larger the value, the higher the efficiency of the unit is; if $TFIE_{NLP} = 1$, it reveals that the DMU is efficient that is located on the production technique frontier.

By using the Charnes-Cooper transformation, the above nonlinear programming in Equation (2) could be transferred into the equivalent linear programming as shown below:

$$TFIE^{t}_{LP}(x^{t}_{i}, y^{t}_{i}, b^{t}_{i}) = \min \tau - (1/k)\sum_{k=1}^{k}(S^{x,-}_{k} / x^{t}_{k,i}) \tag{3}$$

$$s.t. \quad 1 = \tau + [1/(l+m)][\sum_{l=1}^{l}(S^{y,+}_{l} / y^{t}_{l,i}) + \sum_{m=1}^{m}(S^{b,-}_{m} / b^{t}_{m,i})]$$

$$\tau x_i = X\Lambda + S^{x,-}_{i}; \quad \tau y_i = Y\Lambda - S^{y,+}_{i}; \quad \tau b_i = B\Lambda + S^{b,-}_{i}$$

$$S^{x,-}_{i}, S^{y,+}_{i}, S^{b,-}_{i} \geq 0; \quad i'\Lambda = \tau; \quad \Lambda \geq 0; \quad \tau > 0$$

If the optimal solutions of linear programming in Equation (3) are symbolized by $(TFIE^{*}_{LP}, S^{x,-,*}, S^{y,+,*}, S^{b,-,*}, \tau^{*}, \Lambda^{*})$, the optimal solutions of nonlinear programming in Equation (2) could be expressed accordingly as follows:

$$TFIE^{*}_{NLP} = TFIE^{*}_{LP}, \quad \lambda^{*} = \Lambda^{*} / \tau^{*} \tag{4}$$

$$s^{x,-,*} = S^{x,-,*} / \tau^{*}, \quad s^{y,+,*} = S^{y,+,*} / \tau^{*}, \quad s^{b,-,*} = S^{b,-,*} / \tau^{*}$$

The global SBM total-factor efficiency for each input and output in i-th DMU could be calculated as below:

$$TFDE_{i,t}^{input} = (x_{i,t}^{input} - s_{i,t}^{input}) / x_{i,t}^{input} \quad (5)$$

$$TFDE_{i,t}^{undesirable\ output} = (b_{i,t}^{undesirable\ output} - s_{i,t}^{undesirable\ output}) / b_{i,t}^{undesirable\ output}$$

$$TFDE_{i,t}^{desirable\ output} = y_{i,t}^{desirable\ output} / (y_{i,t}^{desirable\ output} + s_{i,t}^{undesirable\ output}) \quad (\ )$$

The value of $TFDE_{i,t}^{input}$, $TFDE_{i,t}^{undesirable\ output}$, $TFDE_{i,t}^{desirable\ output}$ also lies between 0 and 1, and the larger the value, the higher the efficiency of the unit is.

4.2 Empirical Model for the Determinants of TFIE

To further explore the determinants of TFIE of Chinese banks, especially the impact of the development of shadow banking on TFIE, we specify the regression model as follows based on existing literature:

$$TFIE_{i,t} = \delta_0 + \delta_1 SB_{t-1} + \delta_2 CB_{i,t-1} + \delta_3 MC_{t-1} + \delta_4 CON_{t-1} + \xi_{i,t} \quad (6)$$

$$CB_{i,t-1} = (SIZE_{i,t-1}, OWN_{i,t-1}, NPLR_{i,t-1}, ROA_{i,t-1}, LTDR_{i,t-1}, CAR_{i,t-1})$$

$$MC_{t-1} = (GDPG_{t-1}, INF_{t-1}, FSTGR_{t-1})$$

where:

(i) $TFIE_{i,t}$ is the total factor integrated efficiency of bank i for period t.

(ii) SB_{t-1} is the ratio of shadow banking volume to total bank loans in period $t-1$. According to the 'diverting effect' analyzed in the next section of the paper, a negative relationship between the development of shadow banking and banks' TFIE is predicted.

(iii) $CB_{i,t-1}$ is a matrix of bank-level variables which have been recognized to have significant effects on bank efficiency, including bank size $SIZE_{i,t-1}$, ownership structure $OWN_{i,t-1}$, NPL ratio $NPLR_{i,t-1}$, return on asset $ROA_{i,t-1}$, loan to deposit ratio $LTDR_{i,t-1}$ and capital adequacy ratio $CAR_{i,t-1}$. Based on the existing work, the impacts of bank size and capital adequacy ratio on bank efficiency are ambiguous. On one hand, larger banks tend to have higher bank efficiency for their scale economies in banking (Barth, Lin and Ma et al., 2013) or a specialized workforce (Hou, Wang and Zhang, 2014). On the other hand, the concept of "too big to fail" may decrease managers' incentives for better performance, resulting in lower bank efficiency. Fukuyama and Weber (2009), by investigating Japanese Shinkin banks, find that an increase in bank size will increase bank inefficiency. Higher capital ratio contributes to alleviating agency problems between managers and shareholders, giving the latter greater incentives to monitor managers' performance and ensure that the bank is run efficiently (Chortareas, Girardone and Ventouri,

2012). However, Yin, Yang and Mehran (2013) argue that a higher capital ratio may lead to lower efficiency as the cost of capital is more expensive than deposits. For ownership structure, since state-owned banks are more likely to be directed to support social goals such as creating employment opportunities (Megginson and Netter, 2001) or maximize politician's personal objectives (La Porta, López de Silanes and Shleifer, 2002; Cornett, Guo and Khaksari et al., 2010), lower efficiency is predicted to exist among state-owned banks ceteris paribus. $OWN_{i,t-1}$ equals to one if government is the largest shareholder of a bank. Otherwise, a value of zero will be given to it. Return on asset is introduced here to capture the impact of profitability on bank efficiency. As pointed out by Chortareas, Girardone and Ventouri (2013), larger banking institutions with higher profitability ratios benefit substantially banks' efficiency levels. NPL ratio and loan to deposit ratio are incorporated in the regression model to reflect the influence of credit risk and liquidity risk on bank efficiency, based on the work of Hsiao, Chang and Cianci (2010), Chortareas, Girardone and Ventouri (2012, 2013). According to bad luck (BL) hypothesis, an increase in bank risk causes managers to operate less efficiently by incurring risk monitoring costs in their endeavor to preserve the quality of their asset portfolio (Saeed and Izzeldin, 2014). Thus, a negative relationship between NPL ratio (loan to deposit ratio) and bank efficiency is predicted here. To be noted, the positive effect of loan to deposit ratio on bank efficiency is also evident in some literature (Chortareas, Girardone and Ventouri, 2013; Hou, Wang and Zhang, 2014). As argued by Chortareas, Girardone and Ventouri (2013), banks with higher proportions of loans may increase the pressures on management to effectively deal with credit risk, thus improving the efficiency of the banking institutions.

(iv) MC_{t-1} is a matrix of macro-level variables, including GDP growth rate $GDPG_{t-1}$, annual inflation INF_{t-1} and fiscal surplus to GDP ratio $FSTGR_{t-1}$. The impact of GDP growth rate on bank efficiency is uncertain. Lensink, Meesters and Naaborg(2007), Gaganis and Pasiouras (2013) support a positive relationship and argue that banks locate in more prosperous areas tend to have better access to new technology, while Chortareas, Girardone and Ventouri (2012) think that banks in expanding markets with higher GDP may be less efficient in controlling their costs. Inflation is expect to be negatively related to bank efficiency as the higher interest rate caused by higher inflation rate can raise the interest costs of banks and reduce efficiency in activities such as risk management and evaluation of credit information through greater uncertainty and risk (Saeed and Izzeldin, 2014). Fiscal surplus to GDP ratio is introduced here to reflect the impact of the implicit guarantee (Liu, 2013)[14] from Chinese governments on bank efficiency in the absence of deposit insurance. A negative effect is predicted here since the soft-budget problem is more severe among banks located in an administrative region whose governor has stronger implicit guarantee ability.

(v) CON_{t-1} represents the concentration of banking sector denoted by the Herfindahl-Hirschman index which equals the sum of squared market shares according to bank loans. Actually, no consistent findings about the impact of market concentration on bank efficiency exist until now.

[14] See "The Third Report Related to the Development of Chinese Shadow Banking---A Research on Urban Development Investment Bonds" by Mingdong Liu(2013) from the Institute of World Economics and Politics Chinese Academy of Social Science.

Researchers, such as Chortareas, Girardone and Ventouri (2012), Barth, Lin and Ma et al. (2013) support a negative relationship and they think that more concentrated power gives bank managers less incentives to pursue better performance. While Pruteanu-Podpiera, Weill and Schobert (2008), Fungáčová, Pessarossi and Weill (2013) argue from the perspective of imperfect competition structure of banking markets that greater bank competition among banks may reduce the length of their customer relationships which are aimed at mitigating moral hazard problems, thus leading to lower bank efficiency.

(vi) $\xi_{i,t}$ is the error term.

(vii) $\delta_1, \delta_2, \delta_3, \delta_4$ are the slope coefficients or vectors of coefficient estimates.

It is possible that our results are affected by the endogenous problem: The change of bank efficiency may affect banks' performance in other indicators, and even the whole economy for its important role of providing finance to the real departments. To alleviate this problem, all the explanatory variables are lagged by one period, referring to Lu and Chen (2009) and Marques, Correa and Sapriza (2013).

5 Data and Empirical Analysis

5.1 Data

Our sample consists of an unbalanced dataset of 171 Chinese commercial banks between 2004 and 2012. Regarding bank specialization, we categorize all of these banks into four groups: large commercial banks, joint-stock commercial banks, city commercial banks and rural commercial banks. As shown in Table 1, the sample incorporates all the 5 large commercial banks(making up 3.78% of the total number of observations), i.e. Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank and Bank of Communications, 12 joint-stock commercial banks(making up 8.66% of the total number of observations), i.e. China Citic Bank, China Everbright Bank, Huaxia Bank, China Guangfa Bank, Ping An Bank, China Merchants Bank etc., 103 city commercial banks(making up 64.51% of the total number of observations) and 51 rural commercial banks which includes rural cooperative financial institutions(making up 23.05% of the total number of observations).

Most of the accounting data on commercial banks are gathered by hand from the annual reports of each bank and the "Almanac of China's Finance and Banking". The remaining part of data is drawn from Wind financial database and Bankscope Database.[15] Data on macro-economy are all sourced from the "China City Statistical Yearbook", the "China Statistical Yearbook" or the website of the People's Bank of China. Table 2 shows descriptive statistics of all the variables used for efficiency estimation, based on annual data for the periods 2004-2012. All variables, excluding those ratio ones, are inflation-adjusted to base-year 2005. As shown in the table, almost all of the variables used for TFE estimation are of pretty high standard deviation. For two key variables-risk asset and non-performance loans, the lowest values of them are respectively 38 million and zero in RMB, while the largest values of them amount to 7.61 trillion and 0.74 trillion in RMB respectively. For other variables, deposits, perform loans and equity have the largest

[15] To be noted, for the missing values, we follow the method of Jiang and Chen (2012) to estimate them.

standard deviation, and the means of these variables are respectively 0.25 trillion, 0.15 trillion and 0.02 trillion. The high standard deviations in the table indicate that it is significant to highlight heterogeneity in the estimated TFE of Chinese commercial banks.

5.2 TFE Analysis at the Group Level

Based on global SBM approach, we estimate the actual TFE for 171 Chinese commercial banks between 2004 and 2012. This sub-section is mainly concentrated on analyzing the evolution of estimated TFIE of different bank groups, i.e. large commercial banks, joint-stock commercial banks, city commercial banks and rural commercial banks, when different undesirable outputs are incorporated in bank production process. Model 1 with risk-weighted assets as undesirable by-product can well capture a bank's overall risk especially off-balance-sheet risk exposure, while Model 2 with NPLs as undesirable by-product like other studies mainly focus on the credit risk caused by a bank's on-balance-sheet lending activities.

Table 3 presents the changes of weighted-average (by assets) TFIE in both Model 1 and Model 2 from 2004 to 2012 by group. Considering the overall performance of TFIE for different types of banks during this period first, the estimated efficiency in Model 1 displays a totally different pattern from that in Model 2. Specifically, when we incorporate NPLs into the estimation of TFE like what traditional studies concerned with undesirable production outputs have done (i.e. Model 2), joint-stock commercial banks in China have the highest average TFIE, 0.890 over the whole period, and even in most of the years between 2004 and 2012 such as the years 2006-2008, 2010 and 2012, joint-stock commercial banks also rank first in terms of TFIE. City commercial banks and rural commercial banks have the poorest TFIE performance during the same period, with an average value of 0.791 and 0.816 respectively. However when we include risk-weighted assets as undesirable by-products (Model 1), joint-stock commercial banks only possess an average TFIE of 0.788 over the period, ranking behind large commercial banks (0.855) and even rural commercial banks (0.860). Years such as 2007, 2008 and 2011 even witness TFIEs below 0.7 for joint-stock commercial banks. Rural commercial banks have the highest average TFIE (0.86) during the whole period, and city commercial banks rank last, with an average TFIE of 0.741. Large commercial banks have the second highest TFIE in both Model 1 and Model 2, with an average value of 0.855 and 0.867 respectively.

Actually joint-stock commercial banks are regarded by many researchers as banks with the best performance in China or at least with better performance than large commercial banks, which coincides with the results of Model 2, due to their advantage in cost control, technical application and better governance (See Chang, Hu and Chou et al., 2012; Fungáčová, Pessarossi and Weill, 2013; Yin, Yang and Mehran, 2013; Jiang, Yao and Feng, 2013). However, all these studies ignore the fact that advantages possessed by joint-stock commercial banks have also catalyzed their off-balance sheet activities in recent years through financial innovations, which may lead to biased efficiency evaluation. Take WMPs as an example, by June of 2012 the number of WMPs issued by joint-stock commercial banks account for 42.95%, while that of city commercial banks and large commercial banks account for 28.27% and 21.91% respectively.[16] Hua Xia Bank, one of the joint-stock commercial banks in China, was even confronted with a high probability of default for its WMPs in 2012. In Model 2, when taking the overall risk of banks into account, the

[16] See the report by CNBENEFIT (2013), website: http://money.163.com/13/0722/15/94D8SH7A0025335M.html.

TFIE of joint-stock commercial is much lower than that in Model 1, showing that off-balance-sheet activities and higher risk taking may divert bank managers attention from mundane operational problems (Saeed and Izzeldin, 2014), leading to a decrease in a bank's integrated efficiency. In contrast, rural commercial banks still center on traditional lending activities nowadays due to its limited branches poor human capital and innovation ability etc., with the highest NPL ratios and lowest participation in off-balance-sheet activities in China. This explains why rural commercial banks tend to possess lower TFIE when we treat NPLs as undesirable by-product of bank production process. City commercial bank performed even much worse than rural commercial banks before 2007 when NPLs is considered, while after 2007 they experienced an increasingly improvement in IFIE performance due to a series reforms carried out by the governments, such as attracting foreign strategic investors, restructuring cities commercial banks and allowing them to extend outside their own administrative regions etc. The average TFIE of city commercial banks after 2007 is actually larger than rural commercial banks in Model 2, indicating that rural commercial banks are the worst performing commercial banks in terms of average TFIE after 2007 when NPL is considered.

We then analyze the evolution of TFIE for each type of commercial banks concretely. As shown in Table 3 and Figure 5-8, the average TFIE tend to get lower over the whole period for large commercial banks, joint-stock commercial banks and city commercial banks when risk-weighted assets are incorporated as undesirable outputs, while the average TFIE is higher for rural commercial banks in this case. Specifically, for large commercial banks, both TFIE estimated in Model 1 and Model 2 experienced a decreasing trend between 2005 and 2008, which is mainly due to the technical regression happened in this period caused by the change of macro-policies, credit polies and supervisory regulations (Cai and Guo, 2009; Ke and Feng, 2013). The frequent raising of required reserve rate and tight capital requirement of CBRC jointly impeded the growth of bank loans, making the growth rate of inputs greater than that of "good" outputs (Ke and Feng, 2013). The increase of TFIE for large commercial banks in 2009 in both models and only a slight drop of TFIE in the following year in Model 2 show better abilities for large commercial banks to deal with financial crisis. Chang, Hu and Chou et al. (2012) even find an increasing TFP for large commercial banks while decreasing TFP for joint commercial banks around the 2008 financial crisis. All these indicate that ownership reform, initial public offerings (IPOs) and capitalization etc. indeed have positive effects on the improvement of the performance of large commercial banks. Interestingly, the TFIE gap between Model 1 and Model 2 is more prominent for large commercial banks before 2008, which may be caused by the implementation of a series of regulations to monitor and refrain banks' off-balance-sheet activities after 2008. For example, banks are not allowed to use proceeds from WMPs to buy their own credit assets and at the same time they are required to put back onto their balance sheets the credit assets sold to trust companies through single-investor trust products (HSBC, 2011). For joint-stock commercial banks, a steady increase in the TFIE was evident almost over the whole period, except for a drop from 0.935 by the end of 2008 to 0.876 by the end of 2009, when we incorporate NPLs in the production process. However, the estimated TFIEs tend to be more volatile during the whole period if risk-weighted assets are included in the model. Corresponding to the two rounds of significant growth of shadow banking shown in Figure 2, TFIE of joint-stock commercial banks also experienced two rounds of downward trends, with the first round reaching a bottom of 0.603 in 2007 and the second time reaching a bottom of 0.647 in 2011. For city commercial banks, TFIE

experienced a drop in 2007 and 2008 as joint-stock commercial banks in Model 1 which may be attributed to their participation in off-balance-sheet activities and an increasing in overall risk taking, while in Model 2 TFIE still kept an increasing trend during this period. Besides, drop in TFIE estimated by Model 1 is also much larger for city commercial banks in 2010. Though the evolution of TFIE tend to be more volatile when risk-weighted assets are considered, an increasing trend of TFIE can be found in both models, which indicate that the restructuring policies, foreign strategic investors attraction and other reforms help improve the TFIE of cities commercial banks in recent years. Also due to stricter regulation for off-balance sheet activity, the TFIE gap between Model 1 and Model 2 tend to be smaller for city commercial banks. For rural commercial banks, TFIE in Model 1 and Model 2 also behave totally different, the average TFIE is lower when consider NPLs as undesirable products of bank production process, and it reached the lowest level of 0.545 in 2009, mainly due to the deterioration of the loan quality and the increase of credit risk caused by 2008 financial crisis.

Thus, we conclude that, considering on-balance-sheet lending activities only may over-estimate the overall average TFIE and under-estimate TFIE volatility of large commercial banks, joint-stock commercial banks and city commercial banks, while a model incorporating risk-weighted average can well capture the lower efficiency of these banks during two important periods in China. The first is between 2006 and 2008 when off-balance-sheet activities and overall bank risk taking surge due to the prosperity of Chinese stock market and flooded market liquidity, and the second is between 2009 and 2012 when Chinese shadow banking system embraced its second round of growth due to the strong credit demand and funding strains implemented by the policy authority. In contrast, for rural commercial banks, it is appropriate to be concentrated on the quality of on-balance-sheet lending activities of rural commercial banks for the estimation of bank TFE for their limited participation in off-balance-sheet activities and still severe NPL problems in recent years. Actually the estimated TFIE with NPLs as undesirable by-products can well capture the negative shock to loan quality brought about by 2008 financial crisis for rural commercial banks.

5.3 TFE Analysis at the Regional Level

Table 4 reports the changes of weighted-average (by assets) TFIE in both Model 1 and Model 2 from 2004 to 2012 by region. Considering the overall performance of TFIE for banks located in different regions during the whole period first, both models show that banks in the east of China have the highest average TFIE, with a value of 0.835 in Model 1 and a value of 0.868 in Model 2. Banks in the middle of China rank second in terms of TFIE performance in both models as well, with a value of 0.716 in Model 1 and a value of 0.734 in Model 2. Banks in the west of China have the poorest TFIE performance in these 2 models, but the gap between banks in the west of China and banks in the middle of China is not as large as that between banks in the middle of China and banks in the east of China. For TFIE in each year between 2004 and 2012, banks in eastern China always possess the highest TFIE (except 2008) no matter which undesirable output is included in the production process. And it is also more common for Banks in the middle of China to experience higher TFIE than banks in the west of China during the period. The above heterogeneity in TFIE performance among banks of different regions, especially between banks in eastern and non-eastern region, is closely associated with the unbalanced regional development of

Chinese commercial banks. Eastern areas which incorporate many fast developing cities such as Shanghai, Beijing and Guangzhou etc., provide commercial banks with abundant financial resources (like deposits, loans, financial networks), favorable economic environment and brilliant employees, leading to better governance and high efficiency of banks located in these areas. Actually all of the headquarters of large commercial banks and joint-stock commercial banks lie in the east of China today.

Besides, we also compare the evolutions of TFIE in Model 1 and Model 2 for banks in each region. As shown in Table 4 and Figure 10-13, the average TFIE over the whole period in Model 1 is lower than that in Model 2 in all regions of China, showing that considering only on-balance-sheet lending activities of banks may over-estimate the average bank TFIE in each region. Specifically, for banks in the east of China (Figure 9), the evolution of TFIE follows a trend similar to that of large commercial banks, but with larger gap in TFIE between Model 1 and Model 2. For example, years such as 2007, 2008 and 2011 experienced a gap of 0.115, 0.076 and 0.092 respectively for banks in eastern China, while that for large commercial banks is 0.072, 0.029 and 0.031 accordingly. This may be due to the fact that a lot of joint-stock commercial banks which are also enthusiastic about financial innovation and off-balance sheet activities still develop their business in the region of origin or the fast-growing coastal area, though they are allowed to operate at the national level.[17] For banks in the middle of China (Figure 10), TFIE estimated by Model 1 experienced an increasing trend to 0.782 between 2005 and 2008, then fell to 0.704 between 2009 and 2010, and rose again to 0.840 between 2011 and 2012, while TFIE estimated by Model 2 experienced an increasing trend before 2011, with two slightly drop in 2007 (by 0.015) and 2009 (by 0.030) and fell heavily to 0.604 between 2011 and 2012. The absence of a decreasing trend between 2005 and 2008 when risk-weighted assets are incorporated in the model can be mainly attributed to the sample characteristics that 92.16% of the rural commercial banks, which are still confined to traditional on-balance-sheet lending activities, in the sample locate in the middle of China, making the negative effect of banks' overall risk on TFIE not so significant during this period. Besides, with an increase in the NPL ratio of rural commercial banks, estimated TFIEs which include NPLs as undesirable outputs dropped heavily between 2011 and 2012. For banks in the west of China (Figure 11), the estimated TFIE in Model 1 is higher than that in Model 2 before 2006. However, as the development of Chinese shadow banking and the improvement of local banks' loan quality in recent year, TFIEs accounting for overall risk of banks were lower that accounting for nonperformance loans in most of the years after 2006. TFIE in Model 1 increased from 0.623 to 0.752 between 2004 and 2007, then dropped to 0.667 in 2008, but rose again steadily to 0.789 by the end of 2012 with only a small drop by 0.015 in 2010, while TFIE in Model 2 increased from 0.563 to 0.781 between 2004 and 2008, then dropped to 0.718 between 2009 and 2010, but increased to 0.847 by the end of 2012. The drop of TFIE in 2009 and 2010 when NPLs are treated as undesirable by-products is mainly due to the deterioration of borrower's balance sheet and bank loan quality resulted from 2008 financial crisis. Though the evolution of TFIE is different when we consider different by-products in the model, an overall increasing trend is evident no matter which undesirable output is chosen for banks in the middle and west of China, showing an improvement of the overall bank TFIE performance in non-eastern China. Besides, we should also pay close attention to the unbalance regional development of banks between eastern and non-eastern China, and also to the high volatility of TFIE in these regions, especially when

[17] See García-Herrero, Gavilá and Santabárbara (2006).

overall risk of banks is considered.

5.4 TFE Disaggregation

5.4.1 TFE Disaggregation Analysis by Group

To further explore the individual drivers as well as impediments behind bank TFE, we also estimate the TFE of each input and output. Table 5 and Table 6 respectively reports the weighted-average (by asset) TFE of each input and output when risk-weighted assets and NPLs are incorporated as undesirable by-products of bank production process. Though different input and output factors display different TFE evolution patterns, both models generate a similar ranking in average TFE among all the input and output factors during the whole sample period. The top 3 factors driving the growth of TFE for all banks in the sample are performing loans, equity and net profits no matter which output is regarded as undesirable output. In the last 5 driving factors, four of them are the same, including employee, fix asset, operating expense and administration expense. The ranking shows that as a whole the low performance of Chinese commercial banks in allocating human and fix asset resources, controlling operating costs impede the efficiency improvement of their integrated efficiency. As Wang and Zhu (2011a) have pointed out, over-organization and resource wasting are still evident in China. Besides, considering the ranking in average TFE over the whole period among all the input and output factors by group, employee, fix asset, operating expense and administration expense also rank last for each group in both Model 1 and Model 2. Interestingly, operating expense is the second least efficient factor for large commercial banks and joint-stock commercial banks if risk-weighted assets are considered as undesirable outputs, while it has a higher ranking in TFE if we include NPL as undesirable by-product. The worse TFE performance of operating expense when risk-weighted asset is incorporated in the model shows that off-balance-sheet activities and higher overall risk taking of banks may divert bank managers' attention from mundane operational problems (Saeed and Izzeldin, 2014). Joint-stock commercial banks, which are better at financial innovation, have the lowest TFE of risk-weighted assets (0.806) and operating expense (0.778) among all kinds of banks when risk-weighted assets are included into the model, while they possess the best TFE performance of NPLs (0.952) and operating expense (0.903) when NPLs are considered, also supporting the 'diverting effect' of banks' overall risk.

For the evolution of each factor's TFE, most TFEs of large commercial banks, joint-stock commercial banks and rural commercial banks experienced lower TFE between 2007 and 2009 than the years between 2004 and 2006, when risk-weighted assets are treated as undesirable outputs. Though an increase of TFE for these factors was evident between 2010 and 2012 in this case, the increment was still pretty limited for factors with poor ranking in efficiency, such as employee, fix asset, administration expense, operating expense, interest expense and risk-weighted assets, and some even kept a decreasing trend during this period. Specifically, taking joint-stock commercial banks as an example, the average TFE of operating expenses fell from 0.858 between 2004 and 2006 to 0.702 between 2007 and 2009, then rose little to only 0.778 between 2010-2012. Besides, the average TFE of risk-weighted assets also fell from 0.914 between 2004 and 2006 to 0.725 between 2007 and 2009, and then rose to 0.779 which is far less than 0.914 between 2010 and 2012. This characteristic of the changes in TFE of input and output factors is closely related to

the development of financial innovation ability and increase in off-balance sheet exposure. The over-heated macro-economy, flooded liquidity in stock market, tight monetary policy and less regulations for off-balance-sheet business before the first half of 2008 provide a good environment for financial innovation and shadow banking activities, leading to higher overall bank risk and poorer operating efficiency. Though government authorities have tried their best to monitor and improve stability of Chinese banking system after 2008 through the implementation of a series regulation items, the improvement of TFE for factors with poor ranking in efficiency is still quite limited. In contrast, a decreasing trend of TFE between 2007 and 2009 is absent for most of factors of joint-stock commercial banks, city commercial banks and rural commercial banks when NPLs are incorporated as undesirable outputs. In this case, TFE for most input and output factors experienced a decreasing trend between 2010 and 2012, which may be caused by the deterioration of both banks' and borrowers' balance-sheets after 2008 financial crisis. Banks need to make more effort or use more labor and operating resource to get their loan back. To be noted, for large commercial banks, most factor experienced a decreasing trend between 2007 and 2009, which is mainly due the technical regression of large commercial banks (Cai and Guo, 2009; Ke and Feng, 2013) caused by the change of macro-policies, credit polies and supervisory regulations.

5.4.2 TFE Disaggregation Analysis by Region

Table 7 and Table 8 respectively reports the weighted-average (by asset) TFE of each input and output by region using risk-weighted assets and NPLs as undesirable by-products of bank production process respectively. Employee, fix asset, operating expense and administration expense are included in the last 5 driving factors for banks' whole TFE in every region of China, and this result is robust to the choice of undesirable outputs. Besides, we can also get other results which are also evident in both models. TFEs of employee are the lowest in both models as well as in each region. TFEs of fix assets are the second lowest for banks in the east of China, while it is higher than TFEs of administration and operating expenses for banks located in the middle and west of China. This result is reasonable. Bigger banks such as large commercial banks, which are confronted with serious problems like over-expansion in branches and labors today mainly set their headquarters or develop their business in the more developed east of China, resulting in poorer performance of fix assets for banks in these areas. While banks in the middle and east of China, mainly local commercial banks and smaller branches of large commercial banks, are faced with problems such as the shortage of talent managers and financial resources, poor governance and high operating cost etc., making operating cost inefficiency a more severe problem than fixed asset inefficiency.

We then focus on the differences in TFEs of input and output factors among different regions when different undesirable by-products are included in the model. Considering the average TFE over the whole sample period firstly, operating expense is the third least efficient factor for banks located in the east of China if risk-weighted assets are considered as undesirable outputs, while it has a higher ranking in TFE if NPLs are incorporated in the model. The worse TFE performance of operating expense for banks in the east of China when risk-weighted asset is incorporated in the production process can be also attributed to the unbalanced distribution of large commercial banks and joint-stock commercial banks and the "diverting effect" of banks' overall risk. Moreover, for the evolution of each factor's TFE, most production factors of banks in eastern China experienced

lower TFE between 2007 and 2009 compared with that between 2004 and 2006, and possessed a little higher TFE between 2010 and 2012 in both models, while most factors of banks in the middle and west of China experienced totally different or even opposite TFE evolution paths. These results correspond with the TFE evolution characteristics of different kinds of banks.

5.5 Determinants of Chinese Banks' TFIE

Table 9 and Table 10 presents the regression results of our empirical specification using TFIE estimated by Model 1 and Model 2 respectively. Regression (6) reports fixed-effect estimation results of the basic regression. Regression (1)-(5) are mainly used as additional robustness checks for the obtained results. As shown in the tables, the significant determinants of bank TFIE are quite robust to the choice of undesirable outputs for the estimation of TFIE, except for the difference in the significance of shadow banking variable.

Bank size is positively associated with TFIE, consist with the findings of Hou, Wang and Zhang (2014) whose work also supports the positive effect of banks size in Chinese commercial banking sector. Larger banks in China are more conducive to efficient bank operation due to their scale economies in banking (Barth, Lin and Ma et al., 2013) or a specialized workforce (Hou, Wang and Zhang, 2014). Bank credit and liquidity risks, denoted by NPL ratio and loan to deposit ratio respectively, impose negative impacts on TFIE of Chinese commercial banks, which suggest that banks with higher loan quality and liquidity may have higher efficiency since managers can spend less monitoring costs in their endeavor to preserve the quality of their assets or to take precautions against liquidity risk. Government implicit guarantee ability, represented by fiscal surplus to GDP ratio, is also negatively related to bank TFIE, indicating that parachutes from government may intensify soft-budget problems, resulting in poorer bank performance. In many prefectures and counties of China, local governments have direct bank control or personnel appointment rights, facilitating financial resources grabbing and yardstick competition among local governments. Some city commercial banks are even regarded as the "second finance" of local governments (Qian and Cao et al., 2011), providing strong incentives for local governments to bail out a local bank confronted with default risks. Banks located in a region with better government financial status are usually more likely to be successfully rescued in case of failure and thus care less about efficient operation. Higher market concentration is related with lower TFIE, consistent with the argument of Barth, Lin and Ma et al. (2013) that lower competition caused by more concentrated power decreases the incentive for bank managers to pursue better performance. Besides, for other explanatory variables such as government-ownership, capital adequacy ratio and GDP growth rate etc., though the signs of their coefficients are consistent with our prediction and existing literature, a significant relationship between any one of these variables and bank TFIE fails to exist in China. All these results are quite robust to the choice of undesirable outputs for the estimation of TFIE as well as the choice of regression variables.

We then compare the impact of the development of shadowing banking on bank TFIE when we incorporate different undesirable outputs to estimate the efficiency. As shown in Table 9 and Table 10, a one percent increase in the ratio of shadow banking volume to total bank loans tends to decrease bank TFIE by a larger extent when risk-weighted assets are included in the production process as undesirable by-products. And the impact of shadow banking development on bank efficiency is more significant and robust in this case. Thus, we can conclude that, though a

decreasing trend of NPL ratio, together with progresses in liquidity management techniques and increasingly intensified market competition, contribute to the improvement of bank efficiency in recent years, the increasing participation in shadow banking activities and off-balance sheet exposure poses a new threat to the enhancement of the performance of Chinese commercial banks. Off-balance-sheet activities and higher overall risk taking of banks may divert bank managers' attention from mundane operational problems (Saeed and Izzeldin, 2014). It is important to highlight this off-balance-sheet exposure and incorporated this into the estimation of bank efficiency. Empirical results show that a model with risk-weighted assets as undesirable outputs can better capture the impact of shadow banking involvement, while at the same time reflect other significant determinants predicted by other models.

6 Conclusion

Recent years have witnessed a series of new characteristics of Chinese commercial banks, such as the increasing involvement of traditional banks in shadow banking activities and the unbalanced development among banks of different types or located in different regions, all posing a threat to the further development of banks especially the improvement of bank efficiency. This paper is the first paper to incorporate banks' overall risk, which is represented by risk-weighted assets, endogenously into their asset production process as undesirable by-product for the estimation of banks' total factor efficiency. To highlight the importance of banks' overall risk and unbalanced development of Chinese banking sector, the paper compares TFIE evolutions among banks of different categories and regions at the same time and also the differences between TFIEs estimated with different undesirable outputs. The paper tries to overcome the drawback of limited data sample by investigating a unique sample of 171 Chinese banks, including 5 large commercial banks, 12 join-stock commercial banks, 103 city commercial banks and 51 rural commercial banks, which is the largest data sample concerning with Chinese banking efficiency issues until now as far as we know, making our results more convincing and meaningful.

The estimation results show that evolutions of TFIE differ with the choice of undesirable output and bank characteristics. From the perspective of group differences, a model considering on-balance-sheet lending activities only may over-estimate the overall average TFIE and under-estimate TFIE volatility of large commercial banks, joint-stock commercial banks and city commercial banks, while a model incorporating bank's overall risk can well capture the lower efficiency of these banks during two important periods in China. In contrast, for rural commercial banks, it is appropriate to be concentrated on the quality of on-balance-sheet lending activities to estimate bank TFIE because of their limited participation in off-balance-sheet activities and still severe NPL problems in recent years. Actually the estimated TFIE with NPLs as undesirable by-products can well capture the negative shock to loan quality brought about by 2008 financial crisis for rural commercial banks. From the perspective of regional differences, though considering only on-balance-sheet lending activities of banks may over-estimate the average bank TFIE for any region, banks in the east of China have the highest average TFIE while banks in the west of China take the poorest TFIE performance during the sample period no matter which undesirable output is incorporated. Eastern areas which incorporate many fast developing cities provide commercial banks with abundant financial resources (like deposits, loans, financial networks), favorable economic environment and brilliant employees, leading to better governance

and high efficiency of banks located in these areas.

Besides, to further explore the individual drivers as well as impediments behind bank TFE in China, we also estimate the TFE of each input and output using risk-weighted assets and NPLs as undesirable outputs respectively. Though different input and output factors display different TFE evolution patterns, both cases generate a similar ranking in average TFEs among all the input and output factors during the whole sample period. As a whole, the low performance of Chinese commercial banks in allocating human and fix asset resources, and controlling operating costs impede the improvement of banks' integrated efficiency. In addition, the worse TFE performance of operating expense for joint-stock commercial banks and banks in eastern China when risk-weighted assets are incorporated in the model shows that off-balance-sheet activities and higher overall risk taking of banks may divert bank managers' attention from mundane operational problems (Saeed and Izzeldin, 2014)..

Furthermore, based on newly estimated TFIE, the paper also investigates the determinants of Chinese bank efficiency. Bank size is positively associated with TFIE, showing that larger banks in China are more conducive to efficient bank operation due to their scale economies in banking (Barth, Lin and Ma et al., 2013) or a specialized workforce (Hou, Wang and Zhang, 2014). Bank credit and liquidity risks have negative impacts on TFIE, suggesting that banks with higher loan quality and liquidity may have higher efficiency since managers can spend less monitoring costs in their endeavor to preserve the quality of their assets or to take precautions against liquidity risk. Government implicit guarantee ability is also negatively related to bank TFIE, indicating that parachutes from government may intensify soft-budget problems, resulting in poorer bank performance. All these results are quite robust to the choice of undesirable outputs for the estimation of TFIE as well as the choice of regression variables. For the impact of the development of shadowing banking on bank TFIE, larger and more significant impact is evident when risk-weighted assets are included in the production process, showing that a model with risk-weighted assets as undesirable outputs can better capture the impact of shadow banking involvement, while at the same time reflect other significant determinants predicted by other models.

The results in our paper have several implications for policy: First, as shadow banking activities have significant impacts on the performance of Chinese commercial banks. Policy makers and bank managers are suggested to pay close attention to the detrimental effect of the increasing bank risk especially off-balance sheet exposure today. Laws and regulations are expected to consider the 'diverting effect' of banks' overall risk. Second, providing necessary policy supports for local banks and banks in the middle and west of China may help mitigate efficiency gaps caused by unbalanced development of Chinese commercial banks, for example, encouraging talent managers to work certain period in these banks or providing trainings and appropriate incentive mechanisms for managers in banks of poor performance. Besides, as rural commercial banks are still confronted with traditional NPL problems while off-balance risk exposure is more significant for joint commercial banks, policies made by regulators are also suggested to reflect this heterogeneity. Third, paying closely attention to the over-organization and resource misallocation problems may help improve the efficiency of production inputs such as labor, fixed assets and operating expenses.

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Appendix: Tables and Figures

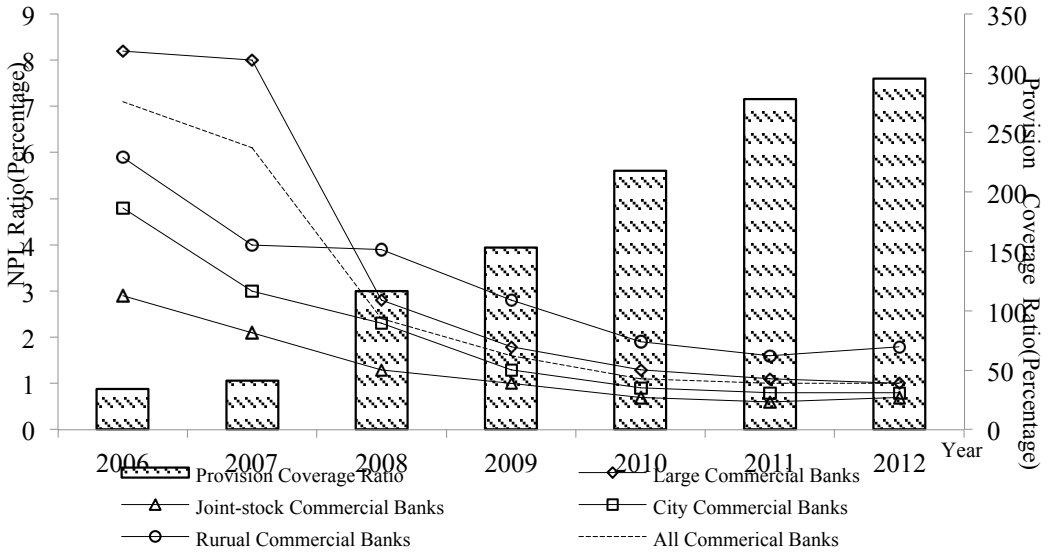


Figure 1 NPL Ratio and Provision Coverage Ratio of Chinese Commercial Banks: 2006-2012[18]

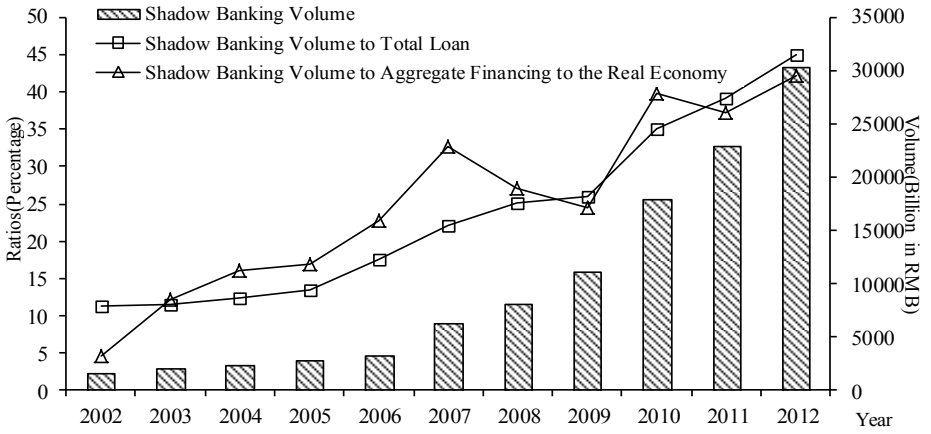


Figure 2 Development of Chinese Shadow Banking (Tier-1) between 2002-2012[19]

[18] Data source: The annual reports of CBRC (2006-2012), website: http://www.cbrc.gov.cn/chinese/home/docView Page/110007.Html. Since the data of the NPL ratios for large commercial banks and joint-stock commercial banks in 2006 are absent in the reports, we collect NPL ratios for each bank and get the weighted average (by assets) NPL ratios in 2006 for large commercial banks and joint-stock commercial banks respectively. Besides, reports only give provision coverage ratio for major commercial banks, i.e. large commercial banks and joint-stock commercial banks, in 2006. We use this number to present NPL ratio for the whole commercial banking system, as major commercial banks has a very large market share (90.55% by assets) then, and the NPL ratios of these major commercial banks in the following years are also quite close to that of the whole commercial banking system.

[19] Data Source: The report of the Chinese Orient Securities (2013): "Shadow Banking: International Prospect and Chinese Case (Second Part)".

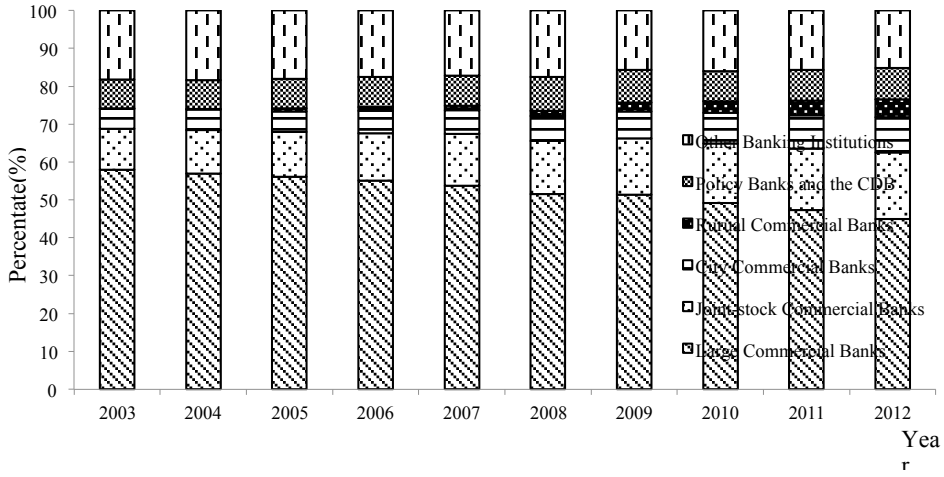


Figure 3 Market Share (by Asset) of Banking Institution from 2003 to 2012[20]

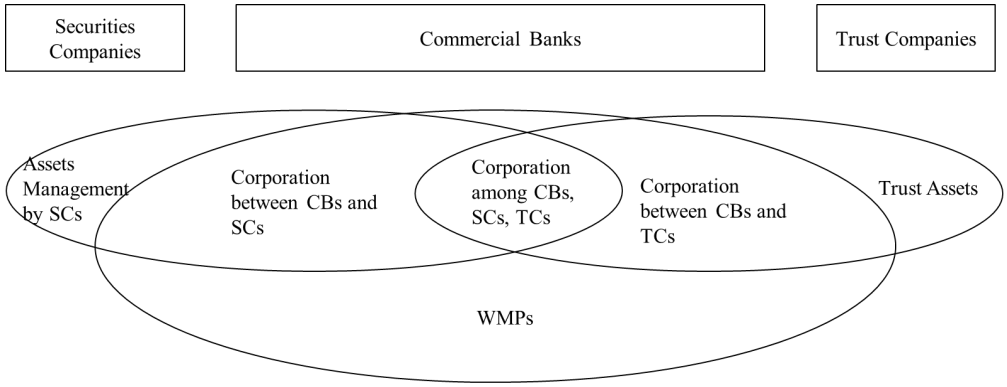
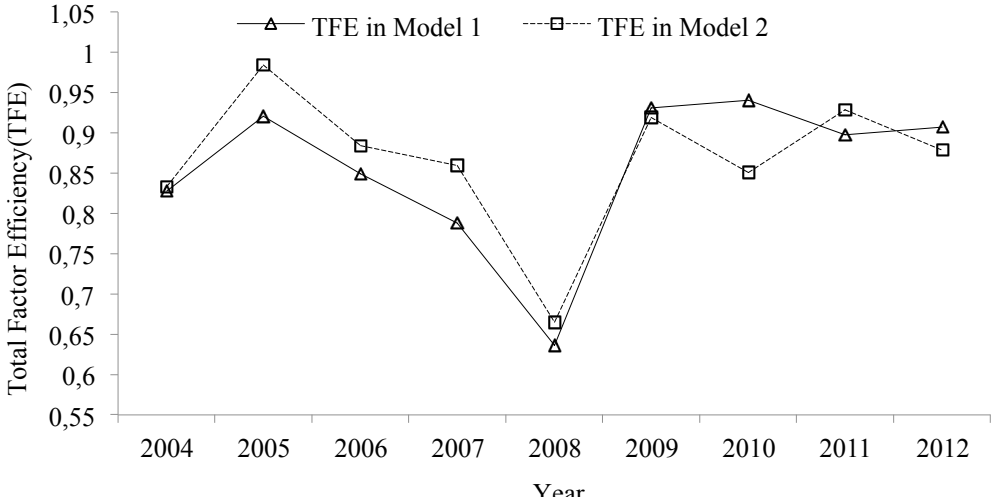


Figure 4 Corporations among CBs, SCs and TCs for WMPs [21]



[20] Data Source: The annual report of CBRC (2012), website: ttp://www.cbrc.gov.cn/chinese/home/docViewPage/110007.Html.

[21] Refer to the report of the Chinese Orient Securities (2013): "Shadow Banking: International Prospect and Chinese Case (Second Part)".

Figure 5 Weighted-Average Total Factor Efficiency of Large Commercial Banks

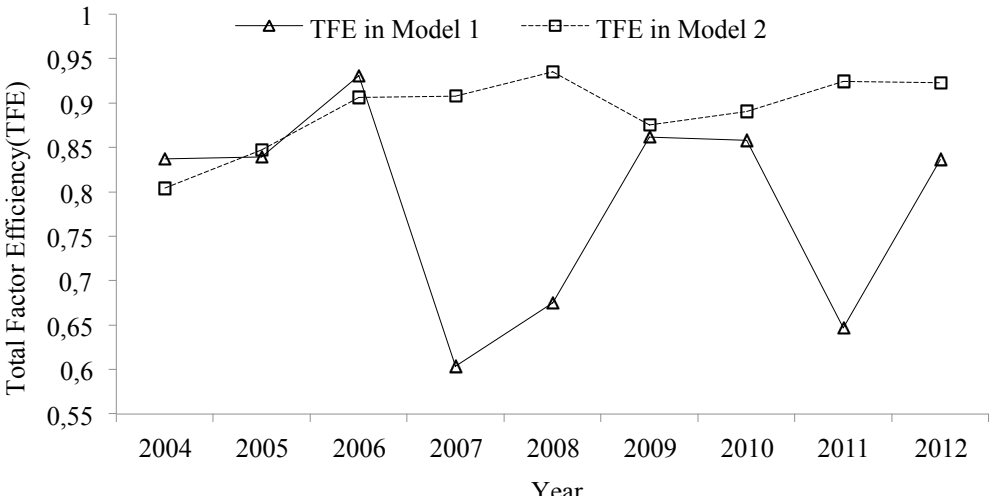


Figure 6 Weighted-Average Total Factor Efficiency of Join-Stock Commercial Banks

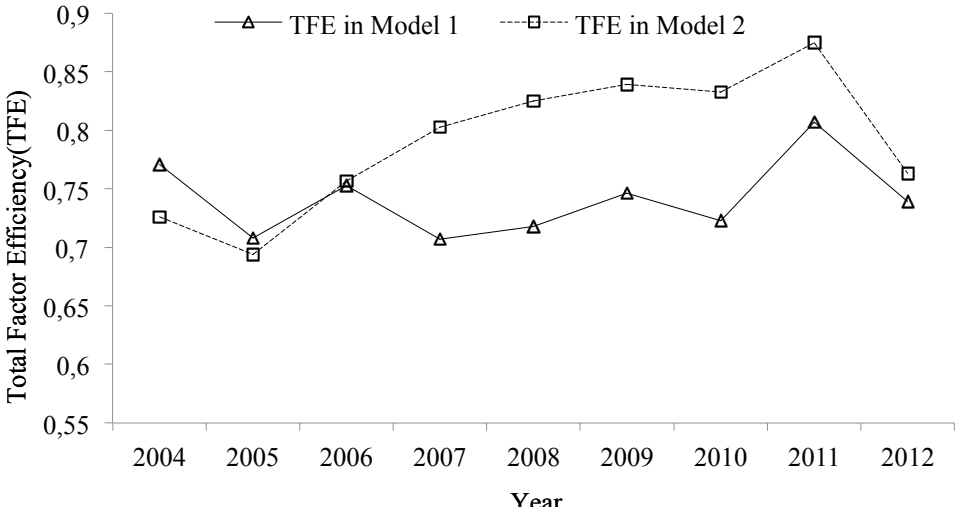


Figure 7 Weighted-Average Total Factor Efficiency of City Commercial Banks

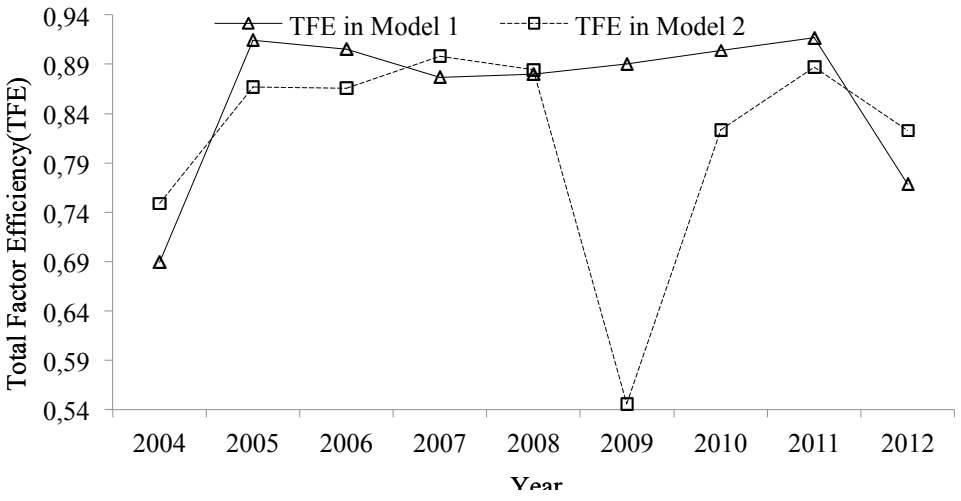


Figure 8 Weighted-Average Total Factor Efficiency of Rural Commercial Banks

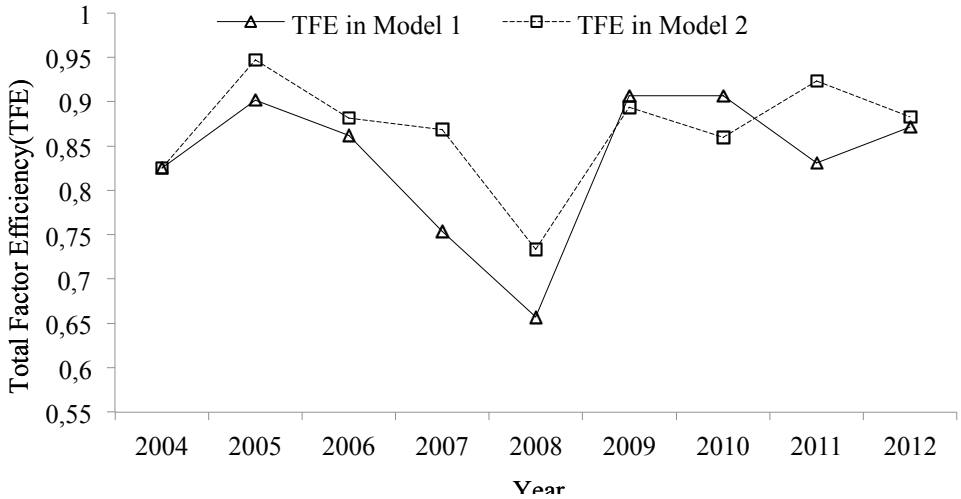


Figure 9 Weighted-Average Total Factor Efficiency of the Banks in the East of China

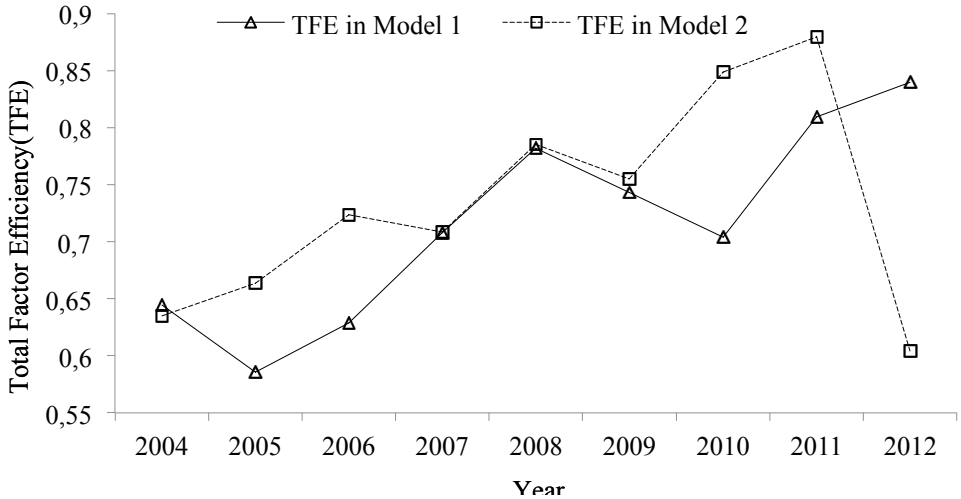


Figure 10 Weighted-Average Total Factor Efficiency of the Banks in the Middle of China

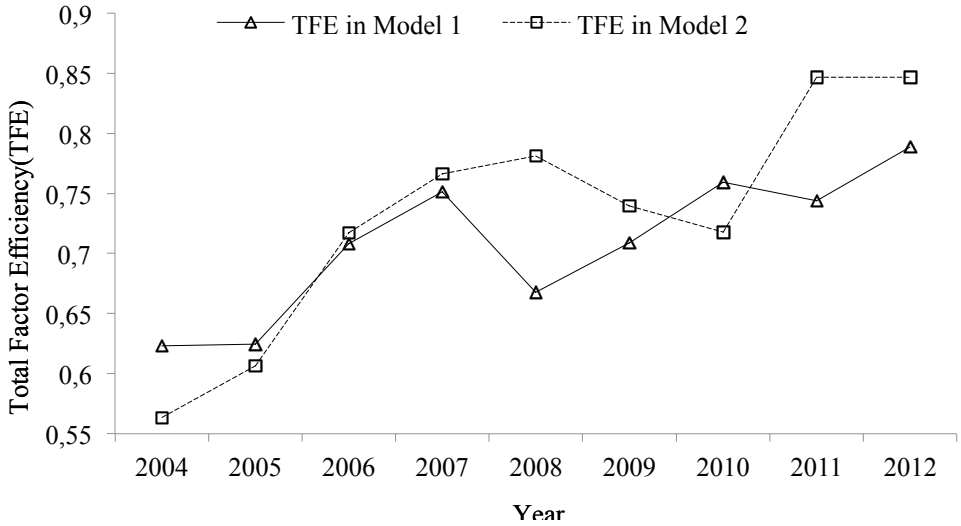


Figure 11 Weighted-Average Total Factor Efficiency of the Banks in the West of China

Table 1 Distribution of the Sample

Type of bank	Number of banks in sample	Percentage (%)
Large commercial banks	5	2.92
Join-stock commercial banks	12	7.02
City commercial banks	103	60.23
Rural commercial banks(including rural cooperative financial institutions)	51	29.83
Total	171	100

Table 2 Descriptive Statistics of All the Variables Used for Efficiency Estimation

Variables	Obs.	Mean	Ste. DeV.	Min	Max
Deposit	1077	2.48e+08	1.02e+09	76215.25	1.09e+10
Equity	1077	1.75e+07	7.62e+07	830.69	9.00e+08
Fix Asset	1077	2.98e+06	1.32e+07	1554.83	1.20e+08

Employee	1077	12302.53	58519.72	128	489425
Administration Expense	1077	3.01e+06	1.24e+07	1128.15	1.24e+08
Operating Expense	1077	1.97e+06	8.16e+06	622.42	7.99e+07
Interest Rate Expense	1077	4.95e+06	1.98e+07	1985.44	2.43e+08
Performing Loans	1077	1.51e+08	6.00e+08	45411.90	6.99e+09
Net Profit	1077	2.93e+06	1.35e+07	-1.55e+6	1.91e+08
Risk Asset	1077	1.70e+08	6.73e+08	38000.54	7.61e+09
Non-Perform Loans	1077	6.53e+06	4.87e+07	0	7.40e+08

Note: The unit for the quantity variables (except employee) in the table is thousand in RMB.

Table 3 Weighted-Average Total Factor Efficiency Change from 2004 to 2012 by Group

Model 1 (With Risk Asset as an Undesirable Output)				
Year	Large Commercial Bank	Joint-Stock Commercial Bank	City Commercial Bank	Rural Commercial Bank
2004	0.828	0.837	0.771	0.689
2005	0.921	0.840	0.708	0.914
2006	0.849	0.931	0.753	0.905
2007	0.788	0.603	0.707	0.877
2008	0.636	0.675	0.718	0.880
2009	0.931	0.862	0.747	0.890
2010	0.941	0.858	0.723	0.904
2011	0.897	0.647	0.807	0.917
2012	0.907	0.836	0.739	0.768
2004-2012	0.855	0.788	0.741	0.860
Model 2 (With Non-Performing Loans as an Undesirable Output)				
Year	Large Commercial Bank	Join-Stock Commercial Bank	City Commercial Bank	Rural Commercial Bank
2004	0.833	0.804	0.726	0.749
2005	0.984	0.847	0.694	0.867
2006	0.884	0.906	0.757	0.865
2007	0.859	0.908	0.803	0.898
2008	0.665	0.935	0.825	0.884
2009	0.919	0.876	0.840	0.545
2010	0.851	0.891	0.833	0.823
2011	0.928	0.924	0.875	0.887
2012	0.878	0.923	0.763	0.823
2004-2012	0.867	0.890	0.791	0.816

Table 4 Weighted-Average Total Factor Efficiency Change from 2004 to 2012 by Region

Model 1 (With Risk Asset as an Undesirable Output)			
Year	Banks in the East of China	Banks in the Middle of China	Banks in the West of China
2004	0.826	0.645	0.623
2005	0.901	0.586	0.625
2006	0.862	0.629	0.708
2007	0.754	0.708	0.752
2008	0.657	0.782	0.667
2009	0.907	0.743	0.709
2010	0.907	0.704	0.759
2011	0.831	0.810	0.744
2012	0.871	0.840	0.789
2004-2012	0.835	0.716	0.708
Model 2 (With Non-Performing Loans as an Undesirable Output)			
Year	Banks in the East of China	Banks in the Middle of China	Banks in the West of China
2004	0.825	0.635	0.563
2005	0.947	0.664	0.606
2006	0.881	0.723	0.717
2007	0.869	0.708	0.767
2008	0.733	0.785	0.781
2009	0.894	0.755	0.740
2010	0.860	0.849	0.718
2011	0.923	0.880	0.847
2012	0.883	0.604	0.847
2004-2012	0.868	0.734	0.732

Table 5 Weighted-Average Efficiency of Each Input or Output Variable by Group (Model 1)

	Year	Deposit	Equity	Fixed Asset	Employee	Administratio -n Expense
Large Commercial Bank	2004-2006	0.940	0.969	0.841	0.872	0.946
	2007-2009	0.853	0.925	0.769	0.752	0.815
	2010-2012	0.960	0.992	0.861	0.931	0.932
	2004-2012	0.918	0.962	0.824	0.852	0.898
Join-Stock Commercial Bank	2004-2006	0.914	0.931	0.879	0.825	0.874
	2007-2009	0.738	0.926	0.734	0.707	0.709
	2010-2012	0.791	0.981	0.813	0.751	0.766
	2004-2012	0.814	0.946	0.809	0.761	0.783
City Commercial Bank	2004-2006	0.960	0.950	0.855	0.458	0.713
	2007-2009	0.884	0.933	0.794	0.354	0.711
	2010-2012	0.892	0.923	0.799	0.493	0.719
	2004-2012	0.912	0.935	0.816	0.435	0.715
Rural Commercial Bank	2004-2006	0.933	0.957	0.898	0.634	0.816
	2007-2009	0.983	0.976	0.928	0.712	0.871
	2010-2012	0.968	0.960	0.913	0.674	0.819
	2004-2012	0.961	0.964	0.913	0.673	0.835
All Banks	2004-2012	0.897	0.958	0.822	0.796	0.860
	Year	Operating Expense	Interest Rate Expense	Performing Loan	Net Profit	Risk Asset
Large Commercial Bank	2004-2006	0.901	0.943	0.988	0.901	0.932
	2007-2009	0.719	0.810	0.994	0.989	0.862
	2010-2012	0.886	0.960	0.996	0.975	0.962
	2004-2012	0.835	0.904	0.992	0.955	0.919

	Year	Deposit	Equity	Fixed Asset	Employee	Administratio -n Expense
Join-Stock Commercial Bank	2004-2006	0.858	0.905	1.000	0.966	0.914
	2007-2009	0.702	0.726	0.983	0.986	0.725
	2010-2012	0.774	0.775	0.983	0.994	0.779
	2004-2012	0.778	0.802	0.989	0.982	0.806
City Commercial Bank	2004-2006	0.809	0.884	0.997	0.850	0.950
	2007-2009	0.770	0.856	0.971	0.942	0.888
	2010-2012	0.796	0.827	0.977	0.974	0.890
	2004-2012	0.792	0.856	0.982	0.922	0.909
Rural Commercial Bank	2004-2006	0.850	0.927	0.991	0.976	0.919
	2007-2009	0.869	0.963	0.998	0.956	0.976
	2010-2012	0.880	0.942	0.987	0.976	0.966
	2004-2012	0.866	0.944	0.992	0.969	0.954
All Banks	2004-2012	0.822	0.881	0.990	0.957	0.895

Table 6 Weighted-Average Efficiency of Each Input or Output Variable by Group (Model 2)

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
Large Commercial Bank	2004-2006	0.973	0.981	0.921	0.905	0.968
	2007-2009	0.907	0.939	0.824	0.823	0.878
	2010-2012	0.936	0.992	0.825	0.905	0.912
	2004-2012	0.939	0.970	0.857	0.878	0.919
Join-Stock Commercial Bank	2004-2006	0.927	0.969	0.890	0.840	0.874
	2007-2009	0.918	0.995	0.902	0.860	0.896
	2010-2012	0.904	0.984	0.900	0.892	0.898
	2004-2012	0.916	0.983	0.897	0.864	0.889
City Commercial Bank	2004-2006	0.951	0.943	0.847	0.461	0.739
	2007-2009	0.982	0.966	0.918	0.473	0.824
	2010-2012	0.942	0.940	0.896	0.612	0.815
	2004-2012	0.958	0.950	0.887	0.515	0.793
Rural Commercial Bank	2004-2006	0.961	0.971	0.889	0.700	0.842
	2007-2009	0.989	0.965	0.951	0.708	0.886
	2010-2012	0.947	0.937	0.907	0.640	0.823
	2004-2012	0.966	0.958	0.916	0.683	0.850
All Banks	2004-2012	0.937	0.971	0.871	0.843	0.904
	Year	Operating Expense	Interest Rate Expense	Performing Loan	Net Profit	Risk Asset
Large Commercial	2004-2006	0.989	0.970	0.998	0.911	0.927
	2007-2009	0.811	0.886	0.981	0.976	0.762

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
Bank	2010-2012	0.882	0.960	0.998	0.971	0.895
	2004-2012	0.894	0.939	0.992	0.953	0.861
Join-Stock Commercial Bank	2004-2006	0.874	0.917	0.976	0.905	0.921
	2007-2009	0.927	0.940	0.998	0.992	0.950
	2010-2012	0.908	0.918	0.999	0.997	0.983
	2004-2012	0.903	0.925	0.991	0.964	0.952
City Commercial Bank	2004-2006	0.795	0.884	0.997	0.826	0.901
	2007-2009	0.866	0.950	0.998	0.943	0.940
	2010-2012	0.873	0.915	0.977	0.977	0.928
	2004-2012	0.845	0.917	0.991	0.916	0.923
Rural Commercial Bank	2004-2006	0.731	0.920	0.987	0.930	0.955
	2007-2009	0.861	0.961	0.997	0.824	0.959
	2010-2012	0.862	0.937	0.990	0.981	0.940
	2004-2012	0.818	0.939	0.991	0.912	0.951
All Banks	2004-2012	0.893	0.935	0.992	0.951	0.888

Table 7 Weighted-Average Efficiency of Each Input or Output Variable by Region (Model 1)

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
Banks in the East of China	2004-2006	0.940	0.964	0.852	0.842	0.924
	2007-2009	0.837	0.928	0.769	0.724	0.792
	2010-2012	0.912	0.985	0.846	0.853	0.874
	2004-2012	0.896	0.959	0.822	0.806	0.864
Banks in the Middle of China	2004-2006	0.897	0.883	0.783	0.283	0.594
	2007-2009	0.962	0.934	0.857	0.285	0.741
	2010-2012	0.961	0.917	0.842	0.451	0.733
	2004-2012	0.940	0.911	0.828	0.340	0.689
Banks in the West of China	2004-2006	0.982	0.937	0.816	0.332	0.664
	2007-2009	0.908	0.869	0.793	0.344	0.684
	2010-2012	0.909	0.911	0.831	0.450	0.730
	2004-2012	0.933	0.906	0.814	0.375	0.693
All Banks	2004-2012	0.897	0.958	0.822	0.796	0.860
	Year	Operating Expense	Interest Rate Expense	Performing Loan	Net Profit	Risk Asset
Banks in the East of China	2004-2006	0.893	0.938	0.990	0.910	0.932
	2007-2009	0.725	0.802	0.991	0.986	0.841
	2010-2012	0.851	0.902	0.991	0.980	0.910
	2004-2012	0.823	0.881	0.990	0.959	0.895

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
Banks in the Middle of China	2004-2006	0.667	0.821	0.992	0.789	0.890
	2007-2009	0.769	0.910	0.991	0.902	0.960
	2010-2012	0.830	0.893	0.988	0.956	0.958
	2004-2012	0.755	0.875	0.991	0.882	0.936
Banks in the West of China	2004-2006	0.698	0.855	0.999	0.721	0.977
	2007-2009	0.768	0.871	0.992	0.915	0.905
	2010-2012	0.859	0.895	0.955	0.983	0.890
	2004-2012	0.775	0.873	0.982	0.873	0.924
All Banks	2004-2012	0.822	0.881	0.990	0.957	0.895

Table 8 Weighted-Average Efficiency of Each Input or Output Variable by Region (Model 2)

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
Banks in the East of China	2004-2006	0.965	0.978	0.914	0.871	0.941
	2007-2009	0.916	0.952	0.850	0.811	0.881
	2010-2012	0.929	0.986	0.851	0.879	0.902
	2004-2012	0.937	0.972	0.872	0.854	0.908
Banks in the Middle of China	2004-2006	0.985	0.942	0.834	0.326	0.705
	2007-2009	0.971	0.946	0.854	0.344	0.777
	2010-2012	0.920	0.868	0.854	0.506	0.765
	2004-2012	0.958	0.919	0.847	0.392	0.749
Banks in the West of China	2004-2006	0.965	0.932	0.750	0.281	0.673
	2007-2009	0.991	0.961	0.863	0.392	0.731
	2010-2012	0.939	0.947	0.899	0.538	0.757
	2004-2012	0.965	0.947	0.837	0.404	0.720
All Banks	2004-2012	0.937	0.971	0.871	0.843	0.904
	Year	Operating Expense	Interest Rate Expense	Performing Loan	Net Profit	Risk Asset
Banks in the East of China	2004-2006	0.958	0.958	0.994	0.906	0.927
	2007-2009	0.839	0.903	0.986	0.972	0.814

	Year	Deposit	Equity	Fix Asset	Employee	Administratio -n Expense
	2010-2012	0.889	0.946	0.997	0.978	0.922
	2004-2012	0.895	0.935	0.992	0.952	0.888
Banks in the Middle of China	2004-2006	0.694	0.897	0.987	0.799	0.850
	2007-2009	0.791	0.920	0.990	0.901	0.913
	2010-2012	0.803	0.904	0.971	0.984	0.900
	2004-2012	0.763	0.907	0.982	0.895	0.888
Banks in the West of China	2004-2006	0.657	0.862	0.998	0.721	0.916
	2007-2009	0.803	0.940	0.996	0.909	0.904
	2010-2012	0.847	0.938	0.994	0.975	0.894
	2004-2012	0.769	0.913	0.996	0.868	0.905
All Banks	2004-2012	0.893	0.935	0.992	0.951	0.888

Table 9 Determinants of TFIE for Chinese Commercial Banks: with Risk-Weighted Assets

Variables	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)
Shadow Banking	-0.335*	-0.567***	-0.616***	-0.556**	-0.572**	-0.587**
	(0.200)	(0.216)	(0.218)	(0.242)	(0.239)	(0.239)
Bank Size	0.119***	0.120***	0.123***	0.120***	0.104***	0.102***
	(0.030)	(0.030)	(0.030)	(0.031)	(0.031)	(0.031)
Government -Ownership	-0.048	-0.042	-0.040	-0.037	-0.031	-0.024
	(0.050)	(0.050)	(0.049)	(0.050)	(0.049)	(0.049)
NPL Ratio		-0.007***	-0.007***	-0.007***	-0.007***	-0.007***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Return on Asset		0.005	0.004	0.004	0.003	-0.000
		(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Loan to Deposit Ratio		-0.053**	-0.053**	-0.053**	-0.060**	-0.060**
		(0.026)	(0.026)	(0.026)	(0.026)	(0.025)
Capital Adequacy Ratio				0.002	0.002*	0.002
				(0.001)	(0.001)	(0.001)

GDP Growth Rate				0.384 (0.396)	0.548 (0.395)	0.588 (0.395)
Inflation				-0.118 (0.367)	0.033 (0.366)	0.056 (0.365)
Fiscal Surplus to GDP Ratio					-1.586*** (0.422)	-1.571*** (0.421)
Banking Sector Concentration						-1.091* (0.631)
Observations	828	828	828	828	828	828
Adjusted R-squared	0.337	0.350	0.351	0.355	0.223	0.158

*Note: t-statistics are in parentheses. * Significant at 0.01 level. ** Significant at 0.05 level. *** Significant at 0.10 level*

Table 10 Determinants of TFIE for Chinese Commercial Banks: with NPLs

Variables	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)
Shadow Banking	-0.142 (0.165)	-0.321* (0.178)	-0.363** (0.180)	-0.336* (0.200)	-0.349* (0.198)	-0.361* (0.198)
Bank Size	0.138*** (0.025)	0.139*** (0.025)	0.141*** (0.025)	0.141*** (0.026)	0.128*** (0.026)	0.127*** (0.026)
Government -Ownership	-0.062 (0.041)	-0.056 (0.041)	-0.054 (0.041)	-0.052 (0.041)	-0.047 (0.041)	-0.042 (0.041)
NPL Ratio		-0.005** (0.002)	-0.004** (0.002)	-0.004** (0.002)	-0.004** (0.002)	-0.004** (0.002)
Return on Asset		0.012 (0.015)	0.011 (0.015)	0.011 (0.015)	0.010 (0.015)	0.007 (0.015)
Loan to Deposit Ratio		-0.056*** (0.021)	-0.055*** (0.021)	-0.055** (0.021)	-0.061*** (0.021)	-0.061*** (0.021)
Capital Adequacy Ratio			0.002 (0.001)	0.002 (0.001)	0.002* (0.001)	0.002 (0.001)

GDP Growth Rate				0.280 (0.328)	0.410 (0.327)	0.443 (0.327)
Inflation				-0.017 (0.304)	0.103 (0.303)	0.121 (0.303)
Fiscal Surplus to GDP Ratio					-1.264*** (0.349)	-1.252*** (0.349)
Banking Sector Concentration						-0.895* (0.522)
Observations	828	828	828	828	828	828
Adjusted R-squared	0.363	0.377	0.373	0.373	0.285	0.253

*Note: t-statistics are in parentheses. * Significant at 0.01 level. ** Significant at 0.05 level. *** Significant at 0.10 level*

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